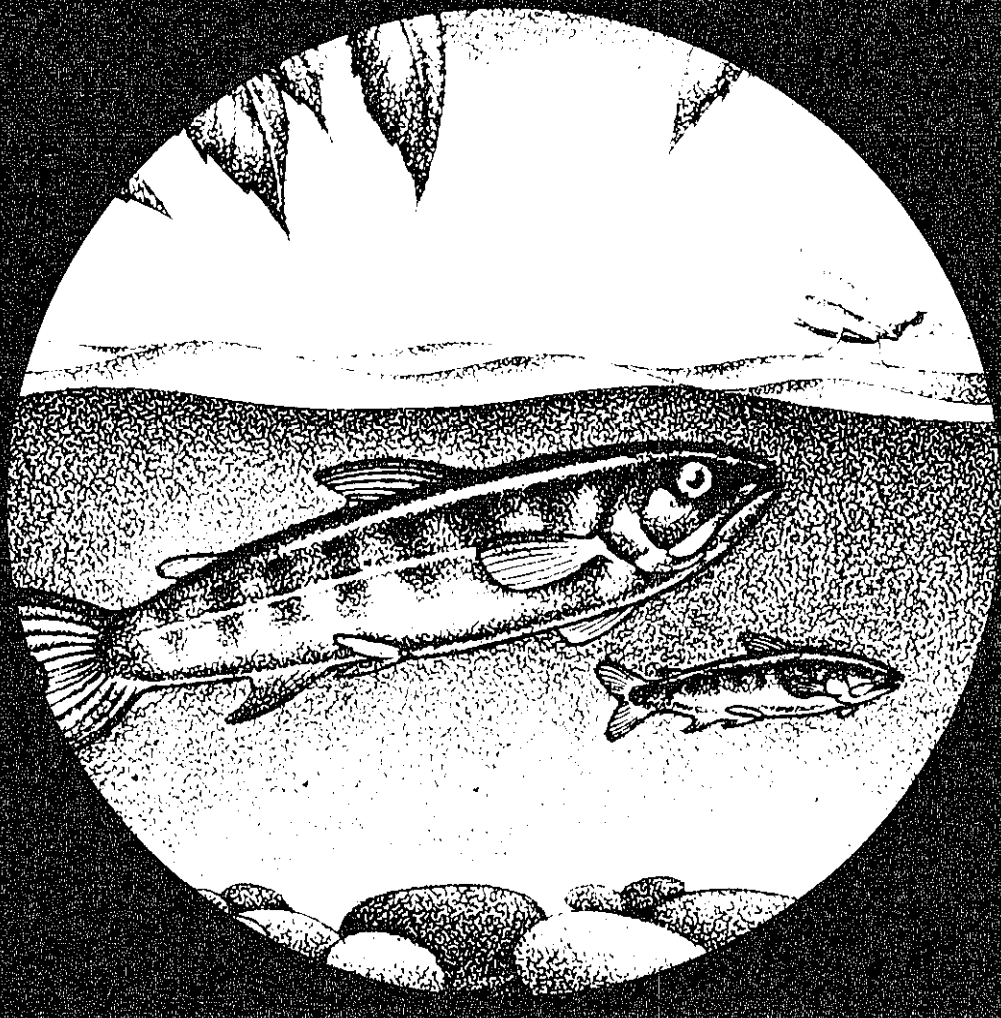
Review of Monitoring Plans for Gas Bubble Disease Signs and Gas Supersaturation Levels on the Columbia and Snake Rivers



July 1994

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REVIEW OF MONITORING PLANS FOR GAS BUBBLE DISEASE SIGNS AND GAS SUPERSATURATION LEVELS ON THE COLUMBIA AND SNAKE RIVERS

Prepared by:

Dr. John Colt,
Dr. Larry Fidler,
and
Dr. Ralph Elston

Montgomery Watson

Prepared for:

U.S. Department of Energy
Bonneville Power Administration
Environment, Fish and Wildlife
P.O. Box 3621
Portland, OR 97208-3621

Project No. 93-008
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Task 5

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Acronyms and Terms

A number of acronyms and terms are used in this report- These terms are listed and defined in the following table:

	Term	Comments
clinical sign		Involving direct observation of a disease; symptoms are a subjective evidence of disease
COE	United States Army Corps of Engineers	
DGS	Dissolved gas supersaturation	
FGE	Fish Guidance Efficiency	Evaluation of the efficiencies of turbine intake screens at The Dalles, McNary, and Little Goose dams
FPC	Fish Passage Center	Responsible for collection and distribution of smolt and adult passage information
GBD	Gas bubble disease	See GBT; older term
GBT	Gas bubble trauma	Formation of bubbles in or on an aquatic animal due to gas supersaturaction; see Sections 5.2 to 5.8
NMFS	National Marine Fishes Service	
SMP	Smolt Monitoring Program	A system-wide juvenile smolt monitoring program on the Snake and Columbia rivers conducted by Fish Passage Center
TGP	Total gas pressure	Expressed as a percent of local barometric pressure
ΔP		Difference between the total gas pressure (mm Hg) and the local barometric pressure (mm Hg)

EXECUTIVE SUMMARY

Montgomery Watson was retained by the Bonneville Power Administration to evaluate the monitoring program for gas bubble disease signs and dissolved gas supersaturation levels on the Columbia and Snake rivers. The results of this evaluation will provide the basis for improving protocols and procedures for future monitoring efforts.

Key study team members were Dr. John Colt, Dr. Larry Fidler, and Dr. Ralph Elston. On the week of June 6 through 10, 1994 the study team visited eight monitoring sites (smolt, adult, and resident fish) on the Columbia and Snake rivers. Additional protocol evaluations were conducted at the Willard Field Station (National Biological Survey) and Pacific Northwest Laboratories at Richland (Battelle). On June 13 and 14, 1994, the study team visited the North Pacific Division office of the U.S. Corps of Engineers and the Fish Passage Center to collect additional information and data on the monitoring programs.

Considering the speed at which the Gas Bubble Trauma Monitoring Program was implemented this year, the Fish Passage Center and cooperating Federal, State, and Tribal Agencies have been doing an incredible job. Thirty-one specific recommendations are presented in this report and are summarized in Section 14 (pages 50 to 53).

The smolt and adult monitoring programs should be reviewed in terms of the data requirements and procedures which are needed to make the program statistically valid. The skin peel procedure used for observation of bubbles in the lateral line does not appear to be valid. Some of the observations for gas bubble trauma were subjective and should be omitted from future programs. Experimental validation of the gas bubble trauma protocols and scoring criteria are needed. Problems occurred with the distribution of both biological and dissolved gas data during parts of the spill period. Formal policies on data reduction, quality assurance, and data distribution are needed for both the biological and physical monitoring programs.

The current level of accuracy and reliability,& the dissolved gas monitoring program on the Columbia and Snake rivers may not be adequate for real-time management of the spill program. This is related to the lack of Standard Operating Procedures (SOPs) for the operation of dissolved gas monitoring equipment, the lack of SOPs for the overall monitoring program, and the lack of a Quality Assurance Program. Input on potential changes to the dissolved gas monitoring program is needed from the fisheries and regulatory agencies.

A number of implementation teams should be formed quickly to develop and implement a revised monitoring program for 1995. Implementation teams are needed for the following areas: program development, training, and Quality Assurance/Quslity Control.

Consideration should be given to conducting experimental studies to define precisely and quantitatively the signs of gas bubble trauma which result from graded sub-acute levels of gas supersaturation exposure and to define the relative susceptibilities of the different species and stocks of fish to gas bubble trauma. These studies would result in a more meaningful and sensitive monitoring program and provide quantification to support standards for detection of gas bubble trauma and interpretation of signs in terms of potential survival of smolts.

REVIEW OF MONITORING PLANS FOR GAS BUBBLE TRAUMA SIGNS AND GAS SUPERSATURATION LEVELS ON THE COLUMBIA AND SNAKE RIVERS

1 .O INTRODUCTION

Emergency spill releases on Columbia and Snake river dams were requested by the National Marine Fisheries Service (NMFS) on May 10, 1994. The purpose of this spill program, which began on May 11, 1994 was to reduce turbine-related mortality by passing more of the smolts over the spillway rather than through the turbines. These spill releases may increase the total gas pressure (TGP) significantly above the current water quality criteria for dissolved gas supersaturation. Even without the emergency spill, total gas pressures in the Columbia and Snake river commonly exceed the dissolved gas criteria. NMFS requested and obtained from Oregon and Washington, an emergency modification of the current TGP criteria through June 20, 1994.

Concerns have been raised about the potential impact of these high dissolved gas levels and the adequacy of the monitoring program for detecting gas bubble trauma (GBT) signs in smolts and adults. The detection of bubbles in fish requires careful examination. Poor holding and sampling procedures could obscure some signs or generate artifacts. Differences in holding and sampling protocols among dams could also result in both positive and negative biases and complicate the interpretation of the monitoring program.

The overall purpose of this project was to review the current monitoring program for dissolved gas supersaturation and GBT and to evaluate its validity. The results of the review of the monitoring program will provide the basis for improving protocols for future monitoring efforts.

2.0 SCOPE

Because of the limited time available to accomplish this evaluation, the project was added as Task 5 to an existing contract (Contract No. DE-AC79-93BP66208) between Bonneville Power Administration and Montgomery Watson. This contract is titled "Allowable Gas Supersaturation For Fish Passing Hydroelectric Dams". The purpose of this contract is to evaluate the impact of high dissolved gas levels on fish passing through turbine or by-pass systems and susceptibility to predation.

The scope for Task 5 is presented below:

Task 5.1 Review the existing written protocols for inspection of smolt and adults.

Task 5.2 Review results of smolt and adult monitoring programs and evaluate in terms of the thresholds required for the formation of the different signs of GBT.

Task 5.3 Review dissolved gas monitoring equipment, location of units, data collection procedures, and data analysis in terms of providing accurate information on the risk to smolts and adults from GBT.

Task 5.4 Observe smolt and adult monitoring at Bonneville and other selected dams on the Columbia and Snake rivers.

Task 5.5 Evaluate holding, sampling, and examination protocols to ensure accurate and valid documentation of gas bubble signs. This could involve some limited holding and sampling of additional fish to reline techniques.

Task 5.6 Develop draft protocols and present to state and federal agencies.

Task 5.7 Finalize draft protocols and distribute to agencies.

Task 5.8 Visit and review the operation of all the monitoring sites on the Columbia and Snake rivers. Suggest modifications to holding and sampling protocols as necessary at a given site because of physical or operational limitations.

Task 5.9 Develop recommendations for future monitoring programs. This could include changes in physical facilities, additional examinations and tests, or expanded number of sites and/or number of fish.

Task 5 is an evaluation of the current monitoring program; detailed interpretation of the clinical signs or potential impact of the observed signs on the smolts, adults, or salmon populations is not within the scope of this task.

3.0 STUDY TEAM

The key study team member include:

Team Member	Area of Expertise
Dr. John Colt	Gas transfer, degassing, hydraulics
Dr. Larry Fidler	Gas bubble trauma
Dr. Ralph Elston	Fish pathology

The personnel used on Task 5 were already under contract to Montgomery Watson under Bonneville Power Administration Contract Number DE-AC79-93BP66208 and are considered experts in the area of GBT and gas supersaturation.

4.0 EXPERIEMENTAL APPROACH AND STUDY EVALUATION

4.1 Experimental Approach

On the week of June 6 through 10, 1994 Larry Fidler, Ralph Elston, and John Colt visited the following monitoring sites on the Columbia and Snake rivers to evaluate the methods used to monitor fish for signs of GBT:

Bonneville Dam

John Day Dam

McNary Dam

Ice Harbor Dam

Resident Fish Monitoring/Net Pens below Ice Harbor Dam

Lower Monumental Dam

Little Goose Dam

Lower Granite Dam

In general, the individual site inspections lasted 1 to'2 hours. Personnel at each site demonstrated the sampling, holding, and examination of fish. Because of time constraints, it was not possible to observe their routine examination of fish. Detailed summaries of field notes for each monitoring site are presented in Appendix A.

Non-exposed fish were examined at the Willard Field Station (National Biological Survey, Department of Interior) and Pacific Northwest Laboratories at Richland (Battelle). The study team was accompanied by Mr. Earl Dawley from the National Marine Fisheries Service (NMFS) for the entire period and Larry Basham from the Fish Passage Center (FPC) during the period of June 6 through 9, 1994.

On June 13 and 14, 1994, Larry Fidler and John Colt visited the North Pacific Division office of the U.S. Army Corps of Engineers (USCOE) and the Fish Passage Center (FPC) to collect additional information and data on the monitoring program

Data analysis and report preparation was completed in Seattle during the period of June 15 through 20, 1994. Additional biological and dissolved gas data was requested from the Fish Passage Center to cover the period from June 12 through the end of the spill on June 20, 1994.

4.2 Data And Study Evaluation

As stated in Section 1, The purpose of this project is to review the current monitoring program for gas supersaturation and GBT and to evaluate if the data is being collected in an accurate and uniform manner. This data is being used to control spill releases on the Columbia and Snake rivers. The collection and analysis of many types of data used in the regulatory process are subject

to detailed to detailed protocols, standard operating procedures, and regulation. In order to evaluate the validity of data and study management, we used existing regulations for similar purposes as a comparison. Examples of these types of regulations are presented below in Table 4.1:

Table 4.1

Examples of Good Laboratory Practices Regulations

Title	Application	Authority/Reference
Good Laboratory Practices Standards	All studies submitted to EPA in support of pesticide registration or FDA involving animal studies	40 CFR 160; Garner et al., 1992; 21 CFR 58
Manual for Certification of Drinking Water Laboratories	Drinking water analysis	40 CFR 141
Environmental Laboratory Accreditation Program	Some programs in the Washington Department of Ecology	Chapter 173-50 WAC

In Washington, the use of accredited laboratories are required for the following programs:

(1) Executive Policy I-22 - "After July 1, 1990, managers responsible for ordering services through regulations, permit (other than wastewater discharge permits) or contractual agreements will ensure the water quality analyses are perfotmed by laboratories accredited by the Quality Assurance Section.

(2) Wastewater Discharge Permit Programs - WAC 173-220-210 (NPDES Permit Program) required use of accredited labs for all major NPDES permittees by July 1, 1992.

(3) Model Toxics Cleanup Program - WAS 173-340-830(2)(a) states that "all hazardous substances analyses shall be conducted by a laboratory accredited under chapter 173-50 WAC, unless otherwise approved by the department".

(4) Puget Sound Estuary Program (PSEP) -All labs supporting PSDDA projects will have to be accredited by selected parameters.

This following discussion is based on good laboratory practices required in 40 CFR 160; and discussed in detail by Garner et al., 1992. Key aspects of good laboratory practices include:

Personnel

> ***Each individual engaged in the conduct of or responsibility for the supervision Of a study shall have education, training, and experience, or combination thereof, to enable that individual to perform the assigned function.***

Equipment

> *Equipment used . . ..shall be of appropriate design* and *adequate capacity to function according to the protocols*

Maintenance and Calibration of Equipment

> *Equipment shall be adequately inspected, cleaned, and maintained.*
>
> *The written standard operating procedures shall set forth in sufficient detail the methods, materials, and schedules to be used in routine inspection, cleaning, maintenance, testing, calibration, andlor standardization of equipment, and shall specify, when appropriate, remedial action to be taken in the event of failure or malfunction of equipment. Written records* shall *be maintained of all inspection, maintenance, testing, calibrating, and/or standardizing operations.*

Standard Operating Procedures

> *A testing facility shall have standard operating procedures in writing setting forth study methods that management is satisfied are adequate to insure the qualily and integrity of the data generated in the course of a study.*

Quality Assurance /Quality Control Group

> *A testing facility shall have a quality assurance /quality control group which shall be responsible for monitoring each study to assure management that the facility, equipment, personnel, methods, practices, records, and controls are in conformance with the regulations in this part. For any given study, the quality assurance unit shall be entirely separate from and independent of the personnel engaged* in the *direction and* conduct *of* the study
>
> *The quality assurance/quality control group shall inspect each study at intervals adequate to ensure the integrity of the study.*

While the specific physical and biological monitoring program considered in this report do not appear to be regulated by federal or state regulations, they should follow commonly accepted good laboratory practices. The results from a monitoring program that does not follow good laboratory practices could be'subject to serious legal challenges in the courts.

5.0 GAS BUBBLE TRAUMA - A REVIEW

In order to understand some of the observations which were made and the conclusions and recommendations which were derived from reviewing the GBT monitoring program, it is important to examine some of the biophysical processes which lead to GBT in fish. The following sections present some of the background information on DGS, the physical and physiological processes which lead to GBT in fish, and descriptions of river conditions and fish behavior which can influence the appearance of signs of GBT.

5.1 Reporting of Dissolved Gas Supersaturation

Before considering the development of GBT in fish, it is instructive to examine the methods by which dissolved gas tensions are reported. Throughout the literature dealing with DGS and GBT in fish, there have been a variety of methods used for calculating and reporting dissolved gas levels. Colt (1986) presented a detailed analysis of these methods. Traditionally, dissolved gas tensions have been reported as Total Gas Pressure (TGP), which is the sum of partial pressures of all dissolved gases. Dissolved gas tensions have also been reported as a percent of atmospheric pressure (TGP%). However, the preferred method is to report dissolved gas tensions as ΔP (Colt 1986, Fidler and Miller 1994, STANDARD METHODS 1992), which is defined as follows:

$$\Delta P \quad pN_2 + pO_2 + pH_2O - pAtm \qquad \text{Equation 1}$$

where

pN_2 = partial pressure of dissolved nitrogen (mm Hg)

$PO2$ = partial pressure of dissolved oxygen (mm Hg)

pH_2O = vapor pressure of water (mm Hg)

$pAtm$ = atmospheric pressure.(mm Hg)

The reason that this method is preferred for describing the physiological signs of GBT is that the potential for bubble growth in fish and the rate of bubble growth are related directly to AP (Harvey et al. 1944, Fox and Herzfeld 1954, Hlastala and Fahri 1973, Yount 1979, Fidler 1988, Shrimpton *et al.* 1990a and b). On the other hand, for any given level of AP, the corresponding TGP or TGP% varies with altitude and barometric pressure (Fidler and Miller 1994). That is, for the same TGP (or TGP%), the potential for bubble growth and the rate of bubble growth will vary with altitude and barometric pressure. Thus, when relating the signs of GBT to dissolved gas tensions, reporting of dissolved gas levels as ΔP does not require corrections for altitude or barometric pressure. Furthermore, since the fundamental measurement of all dissolved gas measuring instruments is AP, it is not necessary to record barometric pressure.

In the remainder of this report ΔP (in mm Hg) will be used as the measure of dissolved gas tensions and as an indicator of thresholds for bubble growth in fish. For the convenience of those who prefer to use the traditional methods, TGP% values based on standard sea level barometric pressure (760 mm Hg) will also be provided where appropriate. However, it should be recognized that a given level of TGP or TGP% represents varying potentials for bubble growth and different bubble growth rates for altitudes or barometric pressures which are different from standard sea level barometric pressure.

Often, in the analysis of the physics of DGS and GBT and in the analysis of data from the literature, it is convenient to work with an effective ΔP. An effective ΔP accounts for the compensating effects of water depth on not only the potential for bubble growth but also on the rate of bubble growth: The uncompensated ΔP is defined as follows.

$$\Delta P_{uncomp} = \Delta P - 83\ h \qquad \text{Equation 2}$$

where

ΔP_{uncomp} = uncompensated ΔP in mm Hg

ΔP = measured ΔP in mm Hg

h = water depth in m

5.2 Signs of Gas Bubble Trauma

The major signs of GBT which can cause death or lead to high levels of stress in fish are:

- Bubble formation in the cardiovascular system, causing blockage of blood flow and death (Bouck 1980, Jensen 1980, Weitkamp and Katz 1980, Fidler 1988, Fidler and Miller 1994).
- Overinflation and possible rupture of the swim bladder in young fish, leading to death or severe problems of overbuoyancy (Shirahata 1966, Jensen 1980, Cornacchia and Colt 1984, Fidler 1988, Shrimpton et al. 1990a and b, Fidler and Miller 1994).
- Extracorporeal bubble formation in gill lamella, causing blockage of respiratory water flow and death by asphyxiation (Fidler 1988, Fidler and Miller 1994).
- Sub-dermal emphysema on body surfaces, including the lining of the mouth. Emphysema of tissue in the mouth may also contribute to the blockage of respiratory water flow and death by asphyxiation (Fidler 1988, White *et al.* 1991, Fidler and Miller 1994).

Depending on dissolved gas levels, various combinations of these signs may be present in fish throughout the Columbia and Snake rivers.

5.3 Development of Gas Bubble Trauma Signs

Each sign of GBT involves the growth of gas bubbles, internal and/or external to the animal. However, for each clinical sign, there is a threshold level of AP which must be exceeded before bubble formation can begin (Fidler 1988, Shrimpton et al. 1990a and b). Still, the activation of GBT signs is not an easily demonstrated cause and effect relationship. This is because bubbles which develop internal to the animal may form in many body compartments, disrupting neurological, cardiovascular, respiratory, osmoregulatory, and other physiological functions (Stroud and Nebeker 1976, Weitksmp and Katz 1980, Fidler 1988, Shrimpton *et al.* 1990a and b). Depending on the level of DGS, there may be multiple signs present in affected animals. GBT may also increase the susceptibility of aquatic organisms to other stresses such as bacterial, viral, and fungal infections (Meekin and Turner 1974, Nebeker et al. 1976, Weitkamp and Katz 1980). All signs of GBT weaken fish, especially larval and juvenile life stages, thereby increasing their

susceptibility to predation (White et al. 199 1). Consequently, ***mortality*** can result from a variety of both direct and indirect effects associated with DGS.

5.4 Biophysics of Gas Bubble Trauma in Fish

In recent years, research at the University of British Columbia, the Canadian Department of Fisheries and Oceans' Pacific Biological Station, and the Montana State University has led to considerable insight into the physiological causes of GBT in fish and the definition of thresholds for specific signs of GBT. In addition, much has been learned about the function of the swim bladder and behavioral responses of fish under conditions of DGS. The results of this research have important bearing on understanding the biophysics of GBT and have played an important role in developing the review of the Columbia and Snake rivers GBT monitoring program.

At the University of British Columbia, Fidler (1984 and 1988) and Shrimpton *et* al. (1990a and b) conducted both theoretical and experimental studies of the biophysics of GBT in rainbow trout. The effects of DGS on physiological parameters such as swim bladder pressures, intracorporeal and extracorporeal bubble formation, blood pressure, blood pH, blood pO_2, and blood catacholamines were examined in terms of water ΔP and pO_2, water depth, and fish size. By combining the results of these studies with an analysis of data from the literature, Fidler (1988) and Shrimpton et al. (1990a and b) were able to establish parameters in a series of equations which predicted the thresholds in wateΔP for specific signs of GBT in fish.

From an analyses of bubble growth processes associated with decompression, cavitation, nucleate boiling, and other similar physical processes, Fidler (1988) derived the following equations which define thresholds in dissolved gas levels for the major signs of GBT.

$$\Delta P_{SB} = 73.89.\ h + 0.15 \cdot pO_2 \qquad \text{Equation 3}$$

$$\Delta P_{EW} = 73.89.\ h + 83.0 \qquad \text{Equation 4}$$

$$\Delta P_{CV} = 73.89.\ h + 0.21 \cdot pO_2 + 83.0 \qquad \text{Equation 5}$$

where

ΔP_{SB} = water ΔP required to initiate overinflation of the swim bladder'in rainbow trout.

ΔP_{EW} = water ΔP required to initiate sub-dermal emphysema and extracorporeal bubble growth between gill lamella.

ΔP_{CV} = water ΔP required to initiate bubble growth in the cardiovascular systems of rainbow trout.

h = water depth at which the fish is located in meters.

pO_2 = partial pressure of dissolved oxygen (mm Hg) in the environmental 'water.

The basis for the equations centers on the concept that nucleation sites are involved in phase changes between liquids and gases (Harvey *et al.* 1944, Fox and Herzfeld 1954, Hlastala and Fahri 1973, Yount 1979). Because surface tension and other surface phenomena impose

restrictions on the stability of these nucleation sites, thresholds in water ΔP are an immediate consequence. The application of these stability criteria to bubble growth in fish and to overinflation of the swim bladder involves additional considerations in terms of gas exchange between the fish and the water environment. Diffusive and convective resistance at the gill reduce blood dissolved oxygen tensions from those of the environmental water (Randall and Daxboeck 1984). Thus, the thresholds for bubble growth in fish differ from those for bubble growth in the environmental water. These principles were incorporated into the derivations presented by Fidler (1988).

In Equations 3, 4, and 5, the factor 73.89 converts water depth to hydrostatic pressure in mm Hg. As the equations imply, water depth is a major factor in establishing the thresholds for signs of GBT. Every meter of depth requires approximately 74 mm Hg of additional ΔP to initiate a particular sign of GBT. Thus, water depth, if available and used by fish, can play an important protective role for fish exposed to high levels of DGS. However, as will be discussed shortly, fish behavior and the time course for bubble growth will establish whether the benefits of water depth are actually realized.

The coefficients multiplying the pO_2 terms in Equations 3 and 5 account for the reduction of dissolved oxygen in arterial blood from that in the environmental water. These terms imply that the ΔP required to initiate swim bladder overinflation and cardiovascular bubble growth increases as water pO_2 increases. This is in agreement with the statistical modeling studies of Jensen et al. (1986) and other data from the literature (Fidler 1988).

Equation 4, which describes the threshold for extracorporeal bubble growth and sub-dermal emphysema, is independent of water pO_2. Sub-dermal emphysema appears to involve direct diffusion of gases from the water to nucleation sites just beneath the skin surface.

The 83.0 constant in Equations 4 and 5 accounts for the combined effects of blood or water surface tension, blood pressure, and the size of microscopic nucleation sites upon which bubble growth m the vascular system or in the environmental water is initiated. In the case of the swim bladder, this parameter is zero due to the large size of the swim bladder (Fidler 1988). It was through a series of laboratory experiments using rainbow trout and an analysis of data from the literature, that a value of 83.0 was established for this parameter (Fidler 1988).

Figure 5.1 shows Equations 3, 4, and 5 plotted in terms of ΔP thresholds for specific signs of GBT versus water depth for a water temperature of 10° C and a water pO_2 of 157 mm Hg (sea level normoxic). From the figure it is evident that at a water depth of 0.0 m, the lowest threshold for GBT is a ΔP of about 24 mm Hg (sea level TGP% = 103%); this corresponds to the threshold for swim bladder overinflation. The next highest threshold occurs at a ΔP of about 83 mm Hg (sea level TGP% ≈ 110.0% at 0.0 m water depth) and is the threshold at which extracorporeal bubbles form between gill lamella and sub-dermal emphysema begins. The highest threshold is that for the development of cardiovascular bubbles and occurs at a water ΔP of about 106 mm Hg (sea level TGP% ≈ 115% at 0.0 m water depth).

5.5 Compensation Depths

In some cases, the depths of Figure 5.1 can be interpreted as compensation depths or those depths below which the particular GBT symptom may or may not occur. However, it is important that care be taken in applying this interpretation. For example, depending on the initial inflation pressure in the swim bladder, which in many situations is determined by fish behavior independent of DGS, the swim bladder would tend to overinflate when a fish moves above the compensation depth. When the fish moves below the compensation depth, the swim bladder would tend to

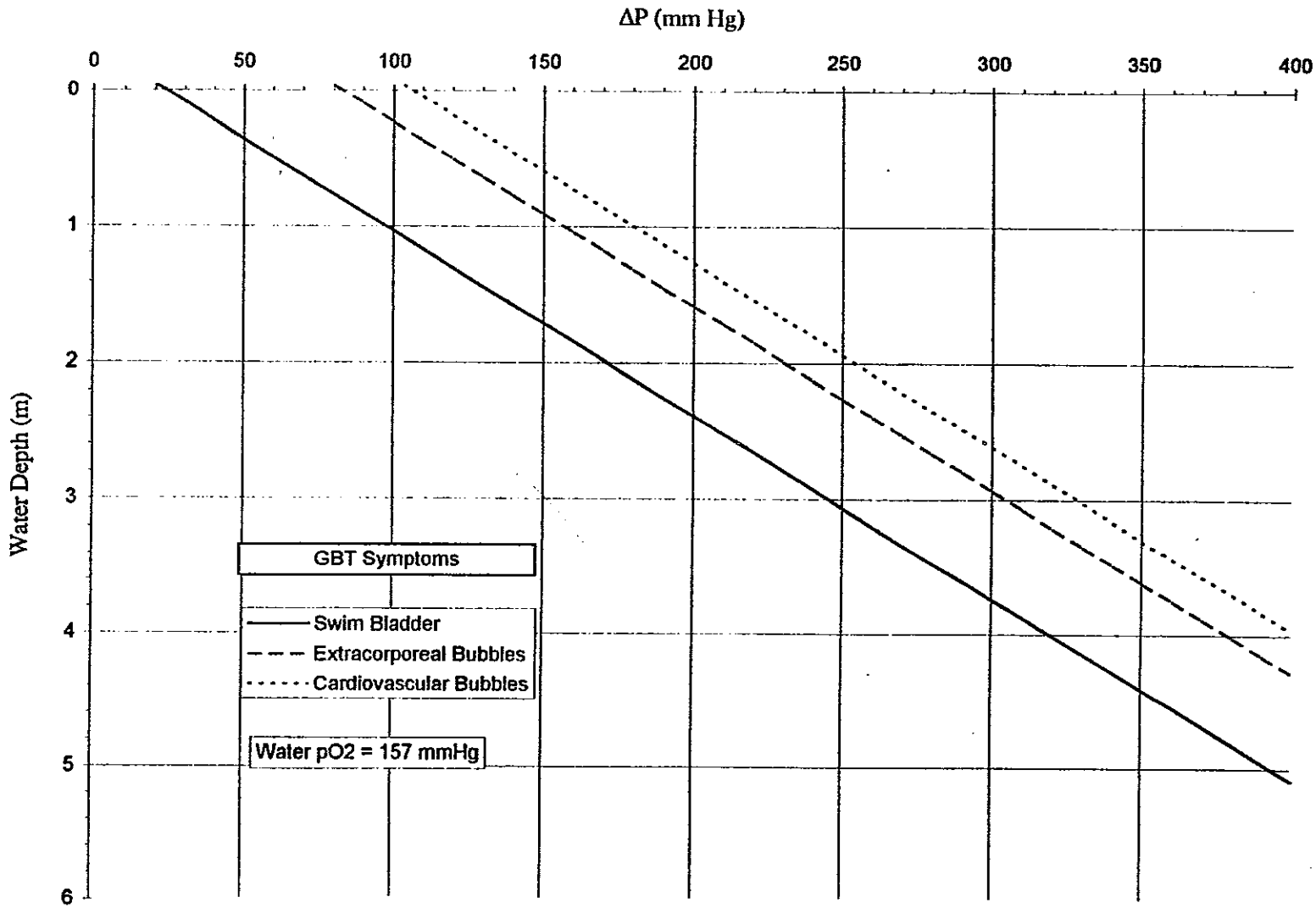

Figure 5.1 Threshold Depths for GBT Signs Versus Water ΔP

deflate. Thus, the threshold line for swim bladder overinflation of Figure 5.1 is a true compensation threshold.

For the growth of intracorporeal and extracorporeal bubbles, a different interpretation of the thresholds of Figure 5.1 is required. If bubble growth has not been initiated and a fish stays below the compensation depth corresponding to the particular bubble growth threshold, bubble growth will not be initiated. However, once the fish moves above the threshold depth and bubble growth begins, moving back below the threshold depth would not stop bubble growth or cause the bubble to collapse. This is because once the bubble radius has increased, growth can continue at ΔP values lower than those required to initiate growth (Harvey et *al.* 1944, Fox and Herzfeld 1954, Hlastala and Fahri 1973, Yount 1979, Fidler 1988, Fidler and Miller 1994).

Alternatively, bubble growth may be initiated as a result of a fish entering supersaturated water with a ΔP above the bubble growth threshold. Once bubble growth has begun, the growth process may continue even though the fish moves into water which is supersaturated but at a ΔP below the threshold value. This has important implications as far as the observation of GBT signs over time. For example, at some point a fish may be exposed to dissolved gas levels high enough to initiate bubble growth. The fish may then move into water that is supersaturated but at levels below the bubble growth threshold. As a result, the bubbles may persist for long periods at dissolved gas levels well below the threshold levels. Thus, it may be incorrect to relate the appearance of bubbles in the cardiovascular system, extracorporeal bubbles in gill lamella, or sub-derrnal emphysema to the dissolved gas levels in the water from which a fish was taken.

5.6 Time Course for Bubble Growth

In order to further understand the conditions under which bubbles can appear in fish exposed to DGS, it is important to examine the time course over which bubble growth takes place. Of particular interest is the time course for bubble growth in the vascular system and the environmental water compared to bubble growth associated with sub-dermal emphysema and in the lateral line.

In some locations of the vascular system, such as in the gill lamella, bubble growth can be quite rapid. In these locations, bubble growth is controlled by surface tension forces at the gas-liquid interface and by diffusive resistance at the gill. For such a bubble, Figure 5.2 shows a plot of bubble radius as a function of time for three levels of dissolved gas supersaturation. As shown, a nucleus of 10×10^{-6} m radius can increase its size by a factor of 10 in a matter of minutes.

Contrasting with this is the time course for bubble growth in the lateral line and beneath external skin surfaces. For these bubbles, growth is controlled mainly by the tensile strength of skin tissue, which is considerably greater than that of water. As a result, bubbles grow very slowly, sometimes taking days or weeks to develop to sizes which can be detected without magnification. When the information regarding time for bubble growth and bubble growth thresholds is combined with migratory fish behavior, a wide range of scenarios is possible for the development and appearance of GBT signs. For example, if river dissolved gas levels are high enough at one location to initiate bubble growth in gill lamella, only a few minutes of exposure are needed to produce bubbles 10 times the radius of the initial nucleation site. Because of the larger bubbles (which in effect are larger nucleation sites), the fish might move into water of lower effective ΔP *(i.e.,* a lower absolute ΔP or alternatively a greater depth in the water column) and bubble growth in the gill lamella may continue. However, the length of exposure time to cardiovascular threshold ΔP levels may not have been sufficient to initiate significant bubble growth in the lateral line of beneath external skin surfaces (Figure 5.1).

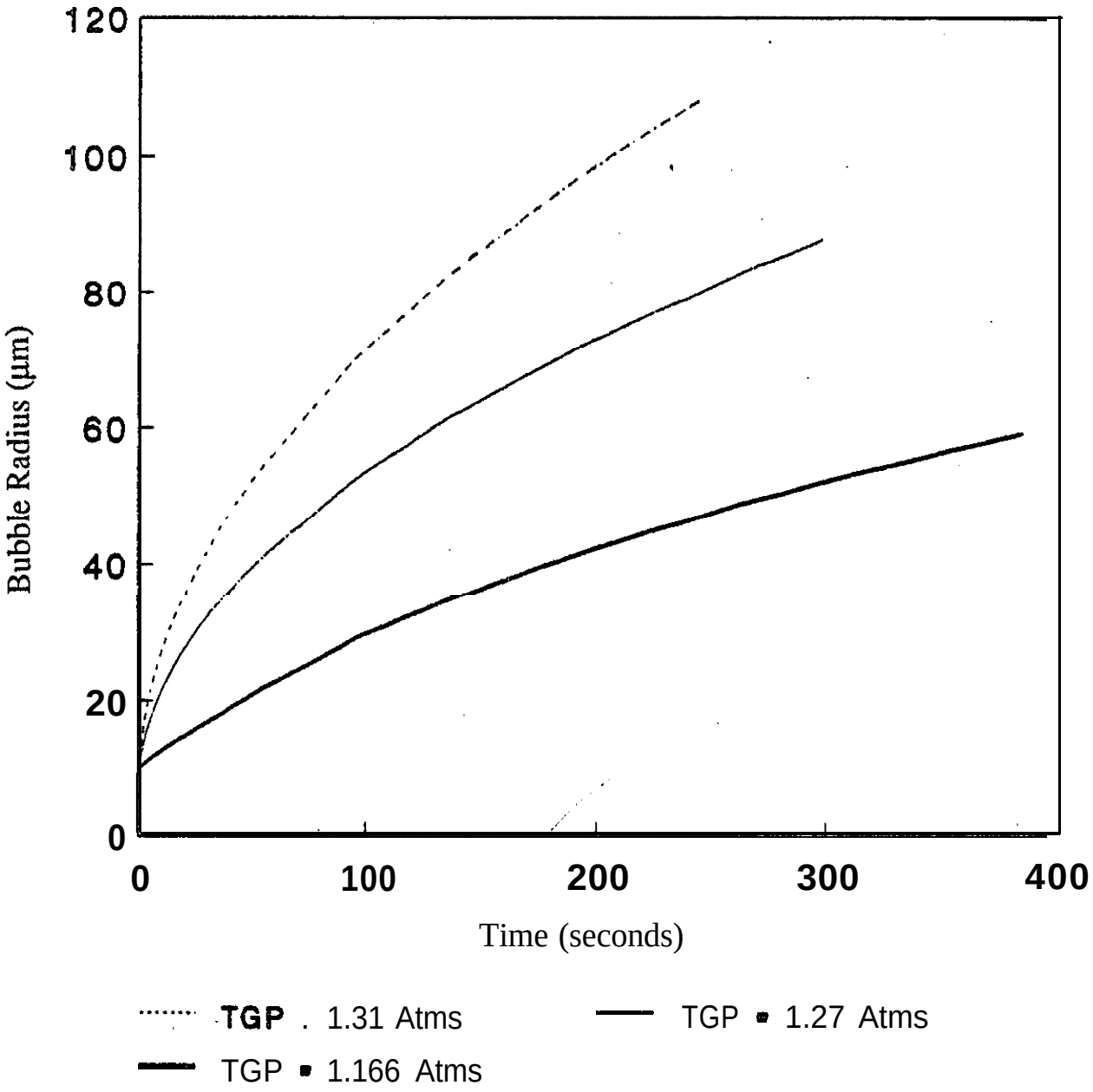

Figure 5.2 Bubble Radius as a Function of Time (Initial nuclei radius - 12 µm; temperature =15 °C; depth 0.0 m)

Furthermore, once the bubble growth has been initiated in the gill lamella, the level of ΔP required to keep these bubbles growing can be below that required to initiate bubble growth in the lateral line and beneath external skin surfaces. As a result of this scenario, attempts to detect signs of GBT through external examinations (even microscopic external examinations) will not reveal the presence of bubbles in the vascular system.

As pointed out above, this leads to further complexities as far as relating observed signs to river dissolved gas levels at the location the fish was captured. That is, a fish which shows signs of bubbles in gill lamella at a dam low on the Columbia or Snake rivers may have encountered the threshold levels of ΔP for bubble growth days or weeks earlier at a dam higher on the river. Alternatively, fish which are not actively migrating during an extended period may develop signs of bubble growth in gill lamella during a very short time of exposure to high levels of ΔP Days or weeks later, when river dissolved gas levels are lower and the fish begins to migrate, the bubbles may be detected in the fish when it is captured in the GBT monitoring program. This scenario applies to both juveniles and adults. In this situation, it would be almost impossible to identify the ΔP conditions or the location on the river which led to the bubble formation. It should be clear that it will be very difficult to relate signs of GBT to specific levels of river ΔP if these levels vary widely over time or river location.

Yet another consideration in terms of the time course for bubble growth is the time required for bubbles to be redissolved once a fish enters water which is of low or zero ΔP. This consideration is important from two standpoints. The first is the time required for fish to recover from the signs of GBT and the second is the effect on monitoring activities: In the first case, little is known about recovery times for fish in water of low ΔP. Weitkamp and Katz (1980) discussed the limited information regarding the recovery of fish in water of zero ΔP (sea level TGP% = 100%). The important consideration from the standpoint of monitoring fish for signs of GBT is the time fish are held in water of low or zero ΔP before examinations are conducted Clearly, the longer fish are held, the fewer the signs of GBT which will be present. The curves of bubble growth shown in Figure 5.2 cannot be applied in reverse for estimating the time for dissolution of bubbles. However, it is expected that the bubble collapse process will occur in about the same time course as the growth process.

Another consideration in terms of the time required for bubble growth is the length of time fish are held in shallow water of high ΔP before examinations are conducted. For example, fish may be migrating at depths where the effective ΔP is very low or even negative (very deep water). At these depths, signs of GBT may not be present. When these fish are captured and held in shallow. water which has a high ΔP , signs of GBT may appear quickly. For example, fish held in water with an effective ΔP = 114 mm Hg may develop bubbles in gill filaments which are 10 times the size of nucleation sites in less than 15 minutes (Figure 5.2). Clearly, such observations do not give a true indication of the presence or absence of GBT signs in these fish.

An almost reverse situation occurs when fish that have already developed signs of GBT are exposed to very deep water where the effective ΔP is low or negative. For example, fish which enter the smolt bypass systems must descend in the water column 15 m or more before they are intercepted by traveling screens. If they spend much time at depth, either before encounter with the traveling screens or in the gate wells, the signs of GBT may disappear. In this case, the absence of signs in these fish when captured in the smolt monitoring program will yield a false indication of the condition of fish in the reservoirs.

5.7 Time to Mortality

Time to mortality for GBT is an important consideration not only from the standpoint of survival of fish in the river, but also from the standpoint of survival when held in shallow, high ΔP water.

Many studies on GBT in fish have yielded considerable information on time to mortality for fish exposed to ΔP levels greater than ≈ 84 mm Hg. These times to mortality range from less than 1 hour up to many days, depending on dissolved gas levels (Fidler and Miller 1994). Because at certain levels of ΔP multiple lethal stresses are present, there are overlapping causes of mortality and, consequently, wide variations in time to mortality. However, one study (Knittle *et.* al. 1980) gave clear information on time to mortality for dissolved gas levels greater than the threshold value for bubble growth in the cardiovascular system (ΔP_{uncomp} = 114 mm Hg). Figure 5.3 shows a plot of time to mortality derived from these data and a best fit regression curve of the data. Fidler (1988) and Fidler and Miller (1994) discussed these data and the corrections in AP which have been applied to arrive at ΔP_{uncomp} values.

5.8 Swim Bladder Overinflation

All Pacific salmon species and all resident fish species of the Columbia and Snake rivers possess a swim bladder which is used to control buoyancy over the wide range of depths encountered throughout their lives. In physostome fishes, such as Pacific salmon and steelhead, the swim bladder is connected to the esophagus by a small-diameter pneumatic duct. The duct serves as a path for filling the swim bladder with atmospheric air to control buoyancy and can also be used to vent air as a means of reducing buoyancy (Harvey 1963). Shrimpton *et* al. (1990a) found that in supersaturated water the swim bladder can become overinflated as a result of dissolved gases diffusing from the water to the bladder by way of the gills and vascular system. When this happens, fish may become severely overbuoyant.

5.8.1 Small Fish

Based on experiments using rainbow trout, Shrimpton et al. (1990a) demonstrated that the symptom of swim bladder overinflation is, for the most part, restricted to juvenile or small fish less than 50 mm in length. Furthermore, it was found that the DGS overpressure required to cause venting of the swim bladder by way of the pneumatic duct increased in a hyperbolic fashion as fish size decreased. Figure 5.4 shows this relationship between swim bladder venting ΔP and fish weight. The ΔP represents the pressure differential between the swim bladder pressure and local hydrostatic pressure at which the swim bladder vents through the pneumatic duct. For very small fish, swim bladder rupture often occurred as water ΔP levels approached 70 mm Hg. It was hypothesized that because of the size of the pneumatic duct in small fish, high surface tension forces at the gas-water interface blocked the movement of gas within the duct (Fidler 1984 and 1988).

In the laboratory environment, Shrimpton er al. (1990b) also found that given the opportunity to use water depth to compensate for overbuoyancy, small rainbow trout would spend a significant amount of time at a water depth where they were neutrally buoyant. Furthermore, as ΔP increased, fish would move deeper in the water column to overcome the effects of swim bladder overinflation. However, it should be emphasized that fish did not go to or below the compensation depth and remain there. Over time, they used the entire water column. Still, on the average, they spent most of the time at the compensation depth or below. It is not known if unrestrained, migrating fish will respond in a similar manner. In a river, migration, schooling, feeding, and avoidance of predators may lead to behavior patterns which offset the responses to overbuoyancy.

For example, fish which are swimming actively (e.g., migrating), may be able to use pectoral fin orientation and hydrodynamic forces to offset any positive or negative buoyancy effects. The behavioral response of fish to buoyancy, especially in relation to their position in the water column and the state of their swim bladders, will be examined in more detail in a subsequent section.

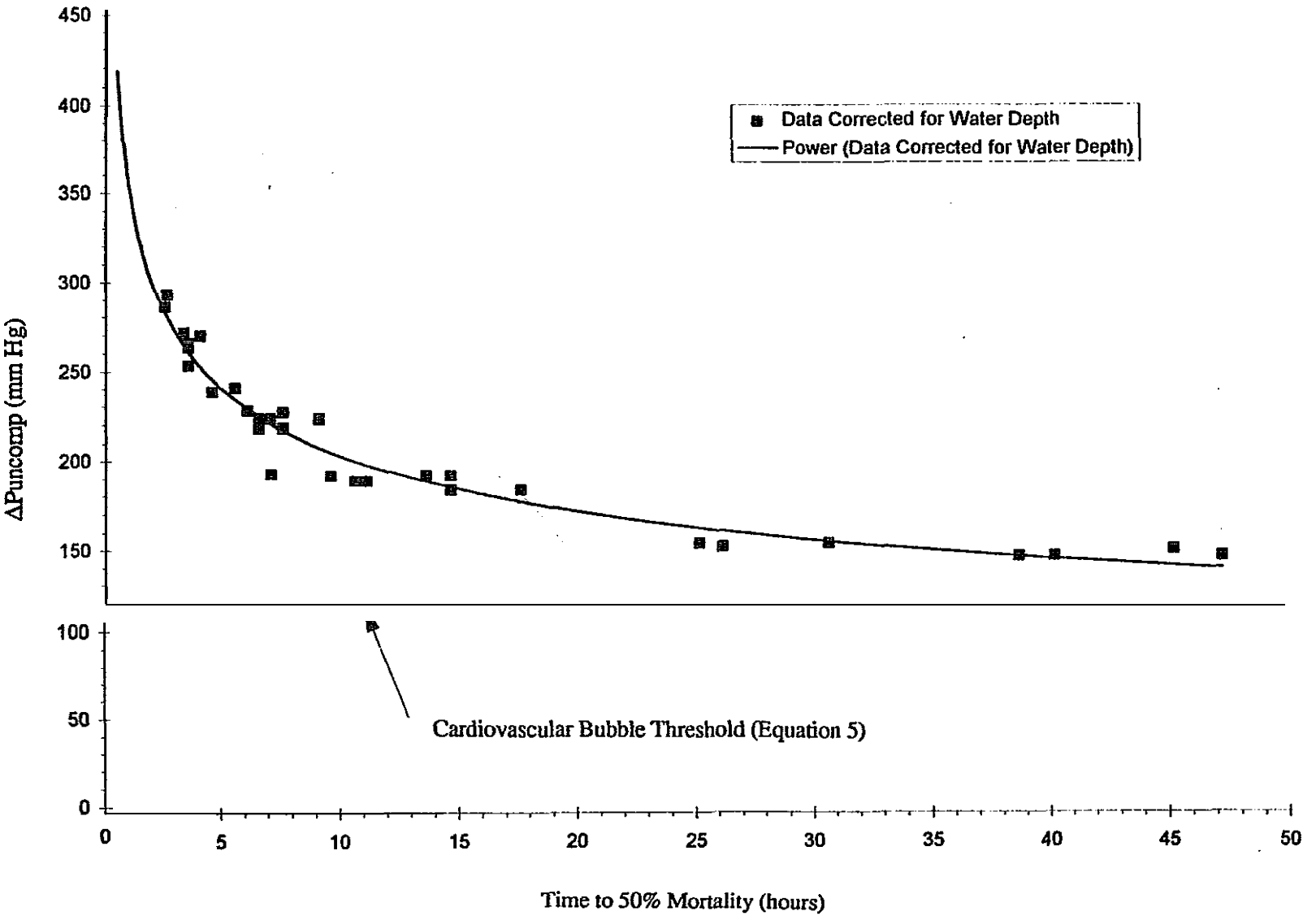

Figure 5.3 Time to Mortality for Cardiovascular Bubble Growth.

5.8.2 Large Fish

Shrlmpton *et al.* (1990a) found that ovetinflation of the swim bladder in large fish (> 200 g) was easily relieved by the venting of gas through the pneumatic duct. This appeared to happen automatically, without any control on the part of the fish, when the pressure rose to a venting threshold level (Figure 5.4). These results would imply that fish larger than 200 g, under normal river conditions, would not encounter a problem of swim bladder overinflation resulting from DGS. As a result, there would be no overbuoyancy stimulus to cause large fish to move below the compensation depth for bubble growth.

It is not known if adult fish will seek depth to avoid the signs of GBT. Consequently, in the absence of an overbuoyancy stimulus, they may not move into deeper water to benefit from the compensating effects of hydrostatic pressure. If these fish remain near the water surface, they will be exposed to the highest levels of uncompensated DGS and exhibit the more severe signs of GBT. In 1968, heavy mortalities of adult chinook salmon occurred at the John Day Dam. If the fish had used the water depth which was available to them at the dam, the losses may have been mitigated. Since these fish did not appear to seek depth, it can be hypothesized that large fish cannot detect DGS and that they do not have any other mechanism, such as overbuoyancy, to motivate them to use deep water to avoid the signs of GBT.

Figure 5.4 Swim Bladder Release Pressure as a Function of Fish Size

6.0 DESCRIPTION OF MONITORING PROGRAM

This section discusses the dissolved gas and GBT data collected on the Columbia and Snake rivers. Detailed information on the monitoring programs is presented in Appendices B and C. A site map of the dams and gas monitoring stations is presented in Figure 6.1. Currently, there are five sources of data on the clinical signs of GBT:

Smolt Monitoring

Fish Guidance Efficiency Monitoring

Adult Salmon Monitoring

Resident Fish Monitoring

Net Pen Exposure

The location of the various gas bubble trauma monitoring sites are presented in Table 6.1. With the exception on the resident fish and netpen exposure below Priest Rapids on the Hanford Reach of the Columbia River, there *is* not monitoring for gas bubble trauma on the Middle Columbia River.

Table 6.1

Location of the Various Gas Bubble Trauma Monitoring Sites

Dam	Smolt Monitoring	Fish Guidance Efficiency Monitoring	Adult Monitoring	Resident Fish Monitoring and Net Pen Exposure
Bonneville	•		•	• below dam
The Dalles		•		
John Day	•			
McNary	•	•		
Ice Harbor			•	• below dam
Lower Monumental	•			
Little Goose	•	•		
Lower Granite	•		•	
Priest Rapids				• below dam

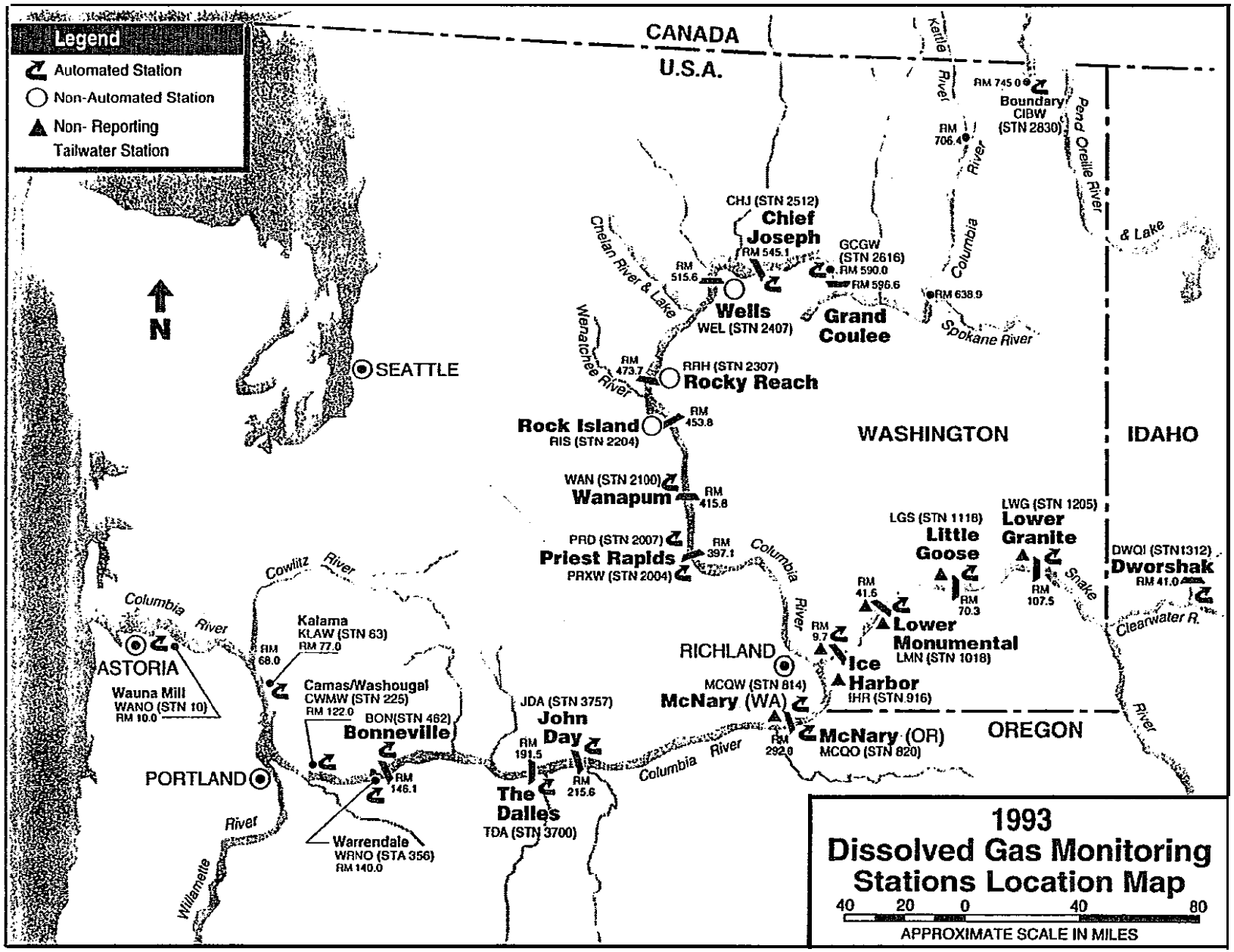

Figure 6.1 Gas Monitoring Stations Location

6.1 Smolt Monitoring

The FPC is conducting a system-wide juvenile smolt monitoring program (SMP) on the Snake and Columbia rivers. The SMP personnel are conducting GBT monitoring at Bonneville, John Day, McNary, Lower Monumental, Little Goose, and Lower Granite dams.

The physical smolt collection systems vary between the different dams. At the collector dams (McNary, Lower Monumental, Little Goose, and Lower Granite), fish collected over the previous 24 hour period are evaluated each morning. At the other dams, smolts are collected from the separator, migrant trap, or gatewell sampler.

6.1.1 External Examination

24 hour samples- McNary, Lower Monumental, Little Goose, and Lower Granite

100 of each salmon species (if available) are obtained from the collector and examined in the morning. The fish are sampled 3 times per week at Lower Granite and every day at the other collector dams.

Migrant trap or gatewell sampler - Bonneville and John Day

100 of each salmon species (if available) are obtained from the separator or gatewell sample and examined. The fish are sampled and examined every day.

6.1.2 External/Internal - Separator, Migrant Trap or Gatewell Sampler- All Dams

100 hatchery chinook salmon or steelhead are collected directly from the separator, migrant trap, or gatewell sampler and examined. These fish are sampled every day. At the collector darn, the fish are collected twice daily. Every other day, 30 hatchery steelhead are sacrificed and examined for external and internal signs of GBT.

The fish for Smolt Monitoring Program at the collector dams (McNary, Lower Monumental, Little Goose, and Lower Granite) are collected over a 24 hour period and examined for external signs of gas bubble trauma only once a day. Therefore, the holding time for these fish varies from minutes up to 24 hours. The 100 hatchery fish collected from the separators, migrant traps or gatewells for external examination were held a much shorter time prior to examination. The holding period depends on the number of fish passing a dam, the physical facilities, and the operator. Typical holding times were difficult to document, but probably ranged from 15 to 45 minutes. The sub-sample of 100 hatchery fish examined for external and internal signs of GBT could have been held up to an additional 2 - 3 hours at some dams prior to examination. The additional holding time prior to examination is a function of the number of fish collected and the time required to perform the external and internal examination.

These data are reported in two separate tables in the *Daily* Dissolved Gus and *Biological Monitoring Data* report prepared by the FPC.

6.2 Fish Guidance Efficiency Studies

NMFS conducted research to evaluate fish guidance efficiencies of turbine intake screens at

Bonneville, The Dalles, McNary, and Little Goose dams. This involved collection of smolts by gatewell clipping and from fyke nets located just downstream from the traveling screens. These tests are conducted at night when the majority of smolts are moving downstream.

The following samples are examined:

100 fish of each salmon species from the gatewell sample are examined for external signs of GBT

10 fish per salmon species from the gatewell sample are anesthetized and examined under a dissecting microscope for the presence of lateral line bubbles

10 fish per salmon species from the fyke net sample are examined under a dissecting microscope for the presence of internal bubbles.

The fish that have been captured by the fyke net are killed by impingement on the net and may have been dead for up to 1 hour prior to examination. Due to time constraints, the study team was unable to observe the collection or examination of fish at the Fish Guidance Efficiency monitoring sites.

These data are reported in separate tables in *the Daily Dissolved Gas* and *Biological Monitoring Data* report prepared by the FPC.

6.3 Adult Salmon Monitoring

Adult salmon migrating upstream were sampled in the fish ladders at Bonneville, Ice Harbor, and Lower Granite dams. Additional observations were made by the Confederated Tribes of the Umatilla and the Oregon Department of Fish and Wildlife at Three Mile Dam on the Umatilla River. The fish were anesthetized and examined visually (a hand lens was used at some sites) for external signs of GBT. No internal examination was being done. Following recovery, the fish were released back into the ladder.

At Bonneville Dam, sampling is conducted 3 days per week for 6 to 8 hours per day. The expected daily catch ranges from 30 to 90 fish.

At Ice Harbor Dam, sampling is conducted 5 days per week for up to 6 hours per day. The fish can be examined for external signs through a window in the trap or by closer examination of anesthetized fish. All anesthetized fish are allowed to recover and are released back into the river 2 miles above the dam. The maximum number of fish sampled is 24 fish per day or 10% of the fish passage count for the previous day. Only smaller 2-ocean fish and 3-ocean hatchery fish are sampled.

At Three Mile Dam, adults are examined for external signs of GBT as part of an existing enumeration and transport program. All the adults at the Three Mile facility are anesthetized and examined.

At Lower Granite Dam, the trap is operated 7 days per week for about 8 hours per day. About 10 % of the fish passing Lower Granite Dam are sampled. The fish are anesthetized and examined for external signs of GBT. Only hatchery fish are examined.

These data are reported in separate tables in the *Daily Dissolved Gas and Biological Monitoring Data* report prepared by the FPC.

6.4 Resident Fish and Invertebrate Monitoring

Resident fish and invertebrate were sampled downstream from Priest Rapids, Ice Harbor, and Bonneville dams by NMFS. Fish are collected by electrofishing, invertebrate pumps, and plankton nets. Below Ice Harbor Dam, beach seining did not work very well and has been eliminated. The number of fish sampled ranges from 70 to 300 per day. A significant number of resident salmon are collected below Priest Rapids and Bonneville dams.

As with most river sampling programs, fish are not found uniformly in the river and must be collected where they can be caught. At the site below Ice Harbor Dam, there is a significant variation in the total gas pressure in the river and most of the fish are collected from the side with the lower total gas pressure. Fish and invertebrates are examined for external signs of gas bubbles under a dissecting microscope.

These data are reported in separate tables in *the Daily Dissolved* Gas *and Biological Monitoring Data* report prepared by the FPC.

6.5 Net Pen Exposure

Net pen exposure of resident and hatchery smolts is being conducted downstream from Priest Rapids, Ice Harbor, and Bonneville dams by NMFS. On a weekly basis, up to 100 resident and hatchery smolts will be placed in net pen enclosures, held in ambient river water for 4 days, and examined for signs of GBT. Half of the fish are held in a shallow pen and half in a deep pen. At the end of the 4-day exposure, only the mortalities are examined for internal signs of GBT.

The data for the hatchery chinook salmon is reported in separate tables in *the Daily Dissolved Gas and Biological Monitoring Ddta* report prepared by the FPC. The data for the resident fish is not included in this report.

6.6 Dissolved Gas Monitoring

The COE maintains dissolved gas monitoring stations at 21 sites on the Columbia and Snake rivers (see Figure 6.1). The monitoring systems are manufactured by Common Sensing, Inc. and measure water temperature, total gas pressure, partial pressure of oxygen, AP, and barometric pressure. The location the station and type of units are presented below:

6.6.1 Forebay Monitoring - Automatic

Monitoring stations are located in the forebays of all the mainstem Columbia and Lower Snake River darns. Data from automated stations are reported on real-time basis to the Columbia River Operational Hydromet Management System (CROHMS). Data are available on an hourly basis from the COE.

6.6.2 Tailrace Monitoring - Automatic

In addition, there are monitoring units downstream from Dworshak and Ice Harbor dams, at Priest Rapids and Bonneville dams, and at Warrrendale (Oregon), at Skamania (Washington), Washougal (Washington), Kalama, (Washington), and Wauna (Oregon). Data from the tailwater stations are also available from the same CROHMS data base, with some time lag.

6.6.3 Tailrace Monitoring - Manual/Fixed Sites

Additional monitoring stations are located downstream from spillways at Lower Granite, Little Goose, Lower Monumental, and McNary dams. Data from the monitors must be down-loaded manually after a 2 to 4 day interval.

6.6.4 Tailrace Monitoring - Manual/Boat

Intermittent monitoring is being conducted by boat downstream from spillways at John Day, The Dalles, and Bonneville dams.

The COE is planning to replace all the manual tailrace monitoring stations with automatic units over the next two years, Duplicate monitoring sites have been installed at Ice Harbor, McNary (south), The Dalles, and Warrendale.

6.7 Data Reporting

Data are faxed or transmitted by modem to the FPC from the field sites on a daily basis. A daily summary report of the data is prepared by the FPC (See Appendix D). This report contains separate summary tables for the individual monitoring programs and dissolved gas information. This report is faxed daily to a number of interested individuals and agencies. The daily summary report is also posted on two computer bulletin boards at FPC (503-230-7563) and CBFWA (503-326.7792) and faxed to a number of individual and organizations. The daily summary report is also transmitted to NMFS for further distribution.

Total gas pressure (TGP) is presented for the automatic sites in terms of the following parameters:

average of the 12 highest hourly values

24 hour average

maximum hourly value

Tailwater total dissolved gas pressures are presented in terms of maximum and minimum on a daily basis for below John Day, The Dalles, and Bonneville dams.

7.0 MONITORING RESULTS

In general, the results of the GBT monitoring review varied depending on sampling location, the dates of examination, whether adults or smolts were being examined, and the type of examination being performed. For the most part, monitoring results were consistent on both the Columbia and Snake rivers. In the case of DGS monitoring, results also varied depending on sampling location and the dates examined. However, results were also consistent for the most part throughout the Columbia and Snake rivers.

A complete set of the daily summaries for biological and dissolved gas monitoring are presented in Appendix D (approximately May 5 to June 30, 1994). The majority of the monitoring activities ceased on June 20, 1994 when the emergency spill stopped. The external examination of smolts conducted by the Smolt Monitoring Program continued until September 16, 1994. The sections which follow will examine these results in further detail. The data presented in Appendix D are not what was presented to the State and Federal Agencies in real-time. This subject will be discussed in detail in Section 12.0.

7.1 Clinical Signs of Gas Bubble Trauma - Smolt Monitoring Program

The following sections summarize the signs of GBT which were observed at the Columbia and Snake river monitoring sites from May 9 through June 30, 1994.

7.1.1 Smolt Monitoring Program - External Examinations of All Fish

This activity involved examination of all smolts captured during the monitoring period. Smolts came from the bypass systems and were collected in holding tanks. The fish could have been held for up to 24 hours before examination. Monitoring procedures involved a non-microscopic external examination of body surfaces including tin rays and the lining of the mouth.

Throughout the period from May 11 through June 30, 1994 very few smolts showed external signs of GBT which could be detected without visual magnification. For most days during this period, fish showed no signs of GBT. The few days in which signs of GBT were noted were, for the most part, at a level of about 2% or less (Table 7.1). However, there were notable exceptions where levels were as high as 7.1% (1 fish out of 14 fish sampled). However, no external signs were detected after May 31, 1994. This may have been due to the decision to reduce spill levels on May 27, 1994.

No external clinical signs of GBT were detected during the period of July 1, 1994 to September 16, 1994. The daily summaries for this period were omitted from Appendix D.

7.1.2 Smolt Monitoring Program - External Examination of Separator Samples

This activity involved non-microscopic visual examination of up to 100 fish twice a day. The data provided by the FPC for this review covered the period May 18 through June 20, 1994. The examinations included hatchery and wild chinook salmon and hatchery and wild steelhead. During this review, it was found that the length of time that fish were held before examination depended on the monitoring site and the period of collection. At times of non-peak migration, fish could be held for up to several hours before examination.

Table 7.1

Gas Bubble Trauma Signs in Smolt Monitoring Program -
External Examinations of All Fish (see Appendix D for data summaries)

Species	Monitoring Site	Date	% Showing External Signs
hatchery chinook salmon	Lower Monumental	5/14/94	0.1
hatchery chinook salmon	Lower Monumental	5/15/94	1.1
hatchery steelhead	Lower Monumental	5/15/94	0.2
wild steelhead	Lower Monumental	5/15/94	0.3
wild sockeye salmon	Lower Monumental	5/15/94	7.1
hatchery chinook salmon	Lower Monumental	5/16/94	0.1
hatchery steelhead	Lower Monumental	5/23/94	1.2
hatchery steelhead	McNary	5/26/94	0.5
hatchery steelhead	McNary	5/28/94	2.2
hatchery steelhead	McNary	5/30/94	1.4
wild steelhead	Bonneville	5/13/94	0.9
wild steelhead	Bonneville	5/15/94	1.1
hatchery steelhead	Bonneville	5/17/94	1.0
wild steelhead	Bonneville	5/17/94	4.0
wild steelhead	Bonneville	5/18/94	1.0
wild steelhead	Bonneville	5/19/94	5.6
hatchery steelhead	Bonneville	5/20/94	1.1
wild steelhead	Bonneville	5/20/94	3.3
wild sockeye salmon	Bonneville	5/26/94	2.7
wild steelhead	Bonneville	5/27/94	1.9
wild steelhead	Bonneville	5/28/94	0.9

For most days of the monitoring period, the prevalence of GBT signs in all species was zero. For the days when GBT signs were observed, levels were at about 2% or less for most species. However, on May 28, 1994 signs of GBT were present in 16.7% (1 fish out of 6 fish sampled) of the wild steelhead examined. Table 7.2 summarizes the prevalence of GBT signs observed at the various monitoring sites. Very few signs of GBT appear in captured fish after May 31, 1994.

7.1.3 Smolt Monitoring Program - Microscopic Examination of Lateral Line and Internal Signs

Data supplied by the FPC for this monitoring activity covered the period from May 13 through June 20, 1994. These data are presented in Appendix D. It will be noted in these data that monitoring did not start on the same date at each monitoring site.

Data collected from this monitoring activity showed a higher prevalence of GBT signs than were observed in any of the non-magnified visual external examinations. The one exception involved the monitoring program at McNary Dam where very few GBT signs were noted in either the non-magnified visual examinations or the magnified examinations involving the lateral line and internal body organs. The greatest contrast between the observations at McNary and the other dams was in the lateral line and internal examinations. Throughout most days of the monitoring period, the sites at Little Goose Dam, Lower Monumental Dam, John Day Dam, and Bonneville Dam all reported some bubbles in internal body compartments and in gill filaments of many of the fish examined. The John Day Dam and Bonneville Dam sites also reported a significant occurrence of bubbles in the lateral lines. At times, the incidence of lateral line bubbles was as high as 100% (Bonneville Dam - 5/31/94) and the incidence of gill filament bubbles was as high as 83% (Bonneville Dam - 5/31/94). Furthermore, with the exception of the McNary Dam, the prevalence of GBT signs increased in a downriver direction from Little Goose Dam to Bonneville Dam. This was consistent and as expected in terms of increased periods of exposure as fish moved down the Snake and Columbia rivers. However, during this entire period, the McNary Dam site reported only one fish having internal bubbles (in the kidney). At present there is no explanation for the contrasting observations between the McNary Darn monitoring site and those at the other dams. It was noted that the examination of the lateral line and skin peel was performed without a microscope and was a significant departure from the recommended procedure which was used at all other sites. However, these departures in protocol do not explain the contrasting observations of bubbles in the gill filaments and internal body compartments since microscopic examination of gill filaments was performed at the McNary monitoring site.

7.1.4 National Marine Fisheries Service - Fish Guidance Efficiency Monitoring

Data supplied by the FPC for this monitoring activity covered the period May 18 through June 2, 1994. During this period, GBT signs were observed on only three days of the monitoring period. These data were observed at the McNary monitoring site only and are shown in Table 7.3 and Appendix D.

7.1.5 National Marine Fisheries Service - Net Pen Monitoring

This monitoring activity covered the period May 9 through June 10,1994. The data supplied by FPC are presented in Appendix D. of the three sites monitored, only the Bonneville and the Ice Harbor sites showed significant signs of GBT. The Priest Rapids site showed no evidence of GBT during the monitoring period. The Ice Harbor site observed levels as high as 37%

Table 7.2

Gas Bubble Trauma Signs in Smolt Monitoring Program - External Examination of Separator Samples (see Appendix D for data summaries)

Species	Monitoring Site	Date	% Showing External Signs
hatchery chinook	Lower Monumental	5/19/94	1.0
hatchery steelhead	Lower Monumental	5/19/94	2.0
hatchery steelhead	Lower Monumental	5/20/94	2.1
hatchery chinook	Lower Monumental	5/21/94	1.1
hatchery steelhead	Lower Monumental	5/21/94	4.2
hatchery chinook	Lower Monumental	5/22/94	2.2
hatchery steelhead	Lower Monumental	5/22/94	2.1
hatchery chinook	Lower Monumental	5/23/94	2.4
hatchery steelhead	Lower Monumental	5/23/94	1.1
hatchery steelhead	Lower Monumental	5/24/94	2.2
hatchery chinook	McNary	5/21/94	1.0
hatchery steelhead	McNary	5/27/94	1.1
wild steelhead	McNary	5/28/94	16.7
hatchery steelhead	McNary	5/30/94	2.2
hatchery steelhead	McNary	6/03/94	1.1
hatchery steelhead	McNary	6/11/94	1.1
hatchery steelhead	McNary	6/17/94	1.1

Table 7.3

Gas Bubble Trauma Signs from Fish Guidance Efficiency Monitoring Program (see Appendix D for data summaries)

Species	Monitoring Site	Date	% Showing External Signs
hatchery chinook	McNary	5/22/94	2.0
hatchery steelhead	McNary	5/24/94	1.2
hatchery steelhead	McNary	5/31/94	2.0

during the period May 23 to May 27, 1994.

7.1.6 National Marine Fisheries Service - Resident Fish Monitoring

This monitoring activity covered the period May 18 through June 20, 1994. The data supplied by FPC are presented in Appendix D and summarized in Table 7.4. Of the three sites monitored, signs of GBT were observed below Ice Harbor and Priest Rapids dams. The site below Bonneville Dam showed ***no*** evidence of GBT during the monitoring period. Clinical signs of GBT were only observed in nonsalmonid fish. The highest levels of GBT were observed at the Ice Harbor site and ranged up to 5.6%.

7.2 Clinical Signs of Gas Bubble Trauma - Adult Monitoring Program

The data supplied for this monitoring activity covered the period from May 18 through June 9, 1994. During this monitoring, no signs of GBT were observed in any of the adult fish captured.

7.3 Dissolved Gas Supersaturation

Dissolved gas levels varied widely along the Columbia and Snake rivers throughout the monitoring period. Data supplied by COE showed that levels varied not only with location but with time. This may have been due, in part, to changes in the overall levels of spill between May and June and to the practice of spilling only at night at Lower Granite, Little Goose, Lower Monumental, McNary, John Day, and Bonneville dams. Spill at The Dalles Dam was continuous during the entire monitoring period. Dissolved gas levels often varied significantly between dam forebay and tailwater monitoring stations. Summary data sheets for dissolved gas data are presented in Appendix D. Based on Department of Environmental Quality's (Oregon) and Department of Ecology's (Washington) emergency modifications to the dissolved gas criteria, spill was managed so that dissolved gas levels did not exceed 120% at locations within approximately 1 mile downstream from each project.

Table 7.4

Gas Bubble Trauma Signs from Resident Fish Monitoring Program
(see Appendix D for data summaries)

Species	Monitoring Site	Date.	% Showing External Signs
Nonsalmonids	Ice Harbor	5/18/94	4.1
Nonsalmonids	Ice Harbor	5/23/94	1.3
Nonsalmonids	Ice Harbor	5/24/94	3.8
Nonsalmonids	Ice Harbor	5/25/94	0.9
Nonsalmonids	Ice Harbor	5/27/94	5.6
Nonsalmonids	Ice Harbor	5/30/94	5.0
Nonsalmonids	Ice Harbor	6/6/94	0.3
Nonsalmonids	Ice Harbor	6/13/94	2.1
Nonsalmonids	IceHarbor	6/15/94	1.8
Nonsalmonids	Ice Harbor	6/16/94	0.5
Nonsalmonids	Priest Rapids	5/26/94	1.3
Nonsalmonids	Priest Rapids	5/31/94	1.3

No attempt was made by the study team to analyze these data for possible correlations of dissolved gas levels with observed signs of GBT. This would require additional information on river water velocities, migration timing at various dams, and the time of release of hatchery stocks. This type of analysis has the potential to provide additional insight as to possible spatial and temporal correlations between signs of GBT and dissolved gas levels. However, a significant number of tagged hatchery fish would be required in order to achieve optimum results from such an analysis.

For monitoring sites at Lower Granite Dam and downstream, 24-hour average forebay *dissolved* gas levels seldom exceeded 120%. Most sites recorded levels of 115% or less. Instantaneous levels over 120% were most frequently recorded in the McNary forebay monitoring sites. However, these only occurred prior to May 31, 1994.

Dissolved gas measurements just downstream from all dams below Lower Granite Dam were generally less than 120% during the monitoring period. However, those obtained below Ice

Harbor Dam were particularly high compared to other downstream monitoring sites. Levels greater than 120% were present during most of the monitoring period, even after spill levels were reduced.

In the upper and middle sections of the Columbia River, the highest TGP% levels recorded were below Wanapum Dam and were 125% or greater until after June 4, In the upper sections of the Snake River, TGP% levels below Dworshak Dam were at 120% on several occasions.

8.0 EVALUATION OF SMOLT MONITORING PROGRAM

The review teams visits to the GBT monitoring sites involved about two hours at each site where demonstrations of monitoring procedures were presented. As a result, it was not possible for the monitoring team to assess the consistency with which the procedures have been applied over the entire monitoring period. In the following sections, each part of the monitoring program will be evaluated.

8.1 Location of Sites

The location of the existing sites do not appear to be entirely adequate for comprehensive monitoring of smolt for signs of GBT. Because of the high levels of DGS below Ice Harbor Dam, smolt downstream from this dam may be experiencing levels of GBT which are not being detected in the current program. The highest level of DGS during the 1994 spill was 134% and occurred below Wanapum Dam. There are no monitoring sites on the mid Columbia River. There is a further problem in that smolt are not being monitored for signs of GBT within the reservoirs between the dams. This problem will be examined in more detail in the following section.

Recommendation: The monitoring program should he expanded to include monitoring at Ice Harbor Dam and at sites in the mid-Columbia River.

8.2 Validity of Samples

The main consideration in monitoring smolt for signs of GBT is whether the smolt that are examined are representative of fish in the Columbia and Snake rivers in general. Based on the discussions of Section 5, there is adequate reason to believe that major differences may exist between smolts taken from the smolt bypass system and smolts `in the reservoirs.

8.2.1 Sample Size

Because the sample size used in the gill and internal examinations is so small, the results of these examinations may not provide a valid statistical description of the presence or absence of GBT in fish of the Columbia and Snake rivers. The review team did not attempt to define the statistical requirements of the monitoring program. However, this question should be addressed before the program continues any further. Without a statistically valid sample size, the monitoring program produces qualitative, rather an quantitative information. Furthermore, many of the questions raised in the following sections will undoubtedly place additional importance on the statistical design requirements of the monitoring program.

The cm-rent sampling procedure for internal clinical signs of gas bubble trauma could also introduce a significant statistical bias into the data. The current procedure involves collection of 100 smolts for external examination and selection of only 30 for internal examination. Statistical subsampling of fish in a tank is not simple. Commonly, smaller or weaker fish are easier to catch. It is probably desirable to use a single random sample of n fish for both the external and internal examinations.

Recommendation: The smolt monitoring program should be reviewed in terms of the data requirements and procedures which are needed to make the program statistically valid. This should include a report which clearly defines the data needs, statistical interpretations, and limitations.

8.2.2 Reservoir Fish

One concern is that fish which pass through the spillways of certain dams (e.g., Ice Harbor Dam), may be subjected to dissolved gas levels considerably higher than those experienced by fish passing through smolt bypass systems and turbines. In the river sections below dam spillways, the exposure to high ΔP levels will persist until the flows from the spillways dissipate some of the DGS to the atmosphere or are mixed with turbine and tributary flows. Because bubbles in gill lamella can grow quickly, fish which are migrating near the surface of these sections of the river may develop lethal signs and perish before they reach the next monitoring site downstream. For example, the only fish which reach the next monitoring site may be those which migrate deep enough in the water column to avoid ΔP_{uncomp} levels that would result in the development of clinical signs of GBT. Once the surviving fish have moved downstream far enough from the dam to where dissolved gas levels are lower, the threat of direct lethal GBT may be reduced or eliminated. If these fish continue to migrate at the same depth or deeper, they may undergo some recovery because the effective ΔP will have been reduced.

Direct observation of mortalities is highly unlikely as these fish will be eaten by birds or fish or sink to the bottom. Consequently, these fish would be missed in the current monitoring program and the overall losses could be substantially higher than the current monitoring program would suggest. Clearly, there is a need to expand the monitoring program to intercept some of the fish that are in river sections downstream from dam spillways.

Recommendation: Fish samples should be collected from the forebay area of each monitoring site and compared to fish from the smolt bypass system for signs of gas bubble trauma. These samples would provide a comparison of the relative degrees of gas bubble trauma severity between the two samples.

8.2.3 Water Depth

Another concern was the effect of fish moving into deep water in order to enter the smolt bypass system. If they are delayed in their passage into the smolt bypass system, either near the traveling screens or in the gate wells, the signs of GBT may disappear because of high hydrostatic pressure. In this case, the effective ΔP may even be negative, which would cause bubbles in the gills and other organs to redissolve quickly. If the delay is long enough, the sub-dermal emphysema may also disappear. As a result, these fish would not be representative of the fish in the dam forebay.

Yet another area of concern is the reverse problem. That *is,* in some cases water DGS levels may be high enough in reservoirs to initiate signs of GBT in fish which occupy shallow water. However, in the reservoirs, many fish may be migrating at depths which protect them from the signs of GBT. If these fish are captured in the bypass system and held for long periods in reservoir water, in shallow raceways, they may develop severe signs of GBT. In this case, the signs of GBT in the captured fish would be more extreme than those of fish migrating in the reservoirs.

At present it is not known how much degassing of water takes place in the smolt bypass system. This will have a direct effect on dissolved gas levels in the smolt holding facilities and the potential for fish to develop signs of GBT. There should be a study conducted which defines the levels of degassing which takes place in these systems.

It should be recognized that all of the potential problems described above may be present to varying degrees at all of the smolt and adult monitoring sites. Numerous studies have shown

variable results in terms of the depths at which smolts and adults migrate (Smith 1974, Swan and Norman 1987, Brege et al. 1988). Consequently, it is not possible to quantify these effects at the present time. However, if the monitoring program is to produce reliable information, these problems must be eliminated or adjustments made in the monitoring procedures which will quantify the effects of these problems. The best solution is to expand the monitoring program to include sampling of fish in the reservoirs above the dams and for some distance downstream of the darn spillways.

Recommendation: Fish samples should be collected downstream from the dam spillways of each monitoring site and compared to fish from the smolt bypass system for signs of gas bubble trauma. These samples would provide a comparison of the relative degrees of gas bubble trauma severity between the two samples.

8.3 Species/Origin of Fish

As will be described in subsequent sections, it appears that the microscopic examinations of the gill lamella and external lateral line provide the most sensitive method for detecting the signs of GBT in fish. However, in the present monitoring program, this procedure is being applied to hatchery steelhead only. It is possible that the signs of GBT observed in hatchery steelhead may not be an accurate indicator of signs of GBT in chinook salmon (wild and hatchery), wild steelhead, and other anadromous species. In order for the monitoring program to accurately reflect the effects of DGS on all species and stocks of the Columbia and Snake rivers, it is imperative that it include background information which quantifies the relative susceptibility of the different species and stocks to GBT. These data can be obtained through comparative laboratory studies.

Another concern is that the quality of fish released from the hatcheries may vary significantly from hatchery to hatchery. It is possible that weaker fish stocks may be more susceptible to GBT than stronger stocks. For example, weaker stocks may not have the energy or other resources to maintain their normal span of migration depths. These fish may migrate closer to the water surface where they are more pmne to developing signs of GBT. It is possible that the fish observed in the monitoring program which are showing signs of GBT may be only those fish from weaker hatchery stocks. Depending on the numbers of these weaker stocks, they may not be good indicators of the presence of GBT in fish of the Columbia and Snake rivers in general. Again, for the monitoring program to provide accurate information, supplemental information will be needed which quantifies the relative susceptibility of different hatchery stocks to GBT.

Recommendation: Comparative studies should be conducted to establish the relative susceptibility of the different species and stocks of anadromous fish in the Columbia and Snake rivers to gas bubble trauma. The results of these studies would serve to validate the monitoring based on hatchery steelhead. Additional information on the migration characteristics of the different stocks (depth in water column, time of travel, length of travel, etc.) may be needed to fully assess the gas supersaturation risk to these different stocks as they migrate down the Columbia and Snake rivers.

Given some of the high dissolved gas levels that were measured in the Snake River, it is possible that fish released from some of the Snake River hatcheries may have had signs of GBT before they were released. In order to verify this problem and its effects on the monitoring program, the program should be expanded to include examination of fish in hatcheries where dissolved gas levels may be elevated.

Recommendation: The fish in the major hatcheries on the Columbia and Snake drainages should be examined for signs of gas bubble trauma prior to release.

8.4 Holding Procedures

Many of the concerns regarding the holding of fish have been described in the previous section. The concerns have to do with the dissolved gas levels in the holding facilities, the depth of the holding facilities, and the length of time over which fish were held The problems are summarized as follows.

If fish are held for long periods in low ΔP water (ΔPs = 10 to 30 mm Hg), the signs of GBT may disappear before the fish are examined. On the other hand, if fish are held in high ΔP water in shallow facilities, signs of GBT may appear in these animals even though signs may not have been present in fish in the reservoir, That is, in the reservoir, fish may be migrating at depths which do not result in GBT. In moderately highly ΔPs, it is also possible for bubble growth to continue at ΔPs below the thresholds levels (Equations 3-5). This would result in a highly prevalence of gas bubble trauma (or more severe clinical signs) in the sampled fish as compared to the fish in the upstream reservoir.

Because of these problems, and the short time required for bubbles to develop in gill lamella, any facet of the monitoring program which requires holding fish for longer than 15 minutes may lead to erroneous results. Therefore, the monitoring program must be simplified to eliminate this possibility.

Based on the dissolved gas monitoring conducted at the smolt by-pass systems (see Appendix A), the ΔP increased in 2 out of the 5 cases *as* the water flowed from the forebay to collection area. The amount of degassing (or air entrainment) that occurs in these systems has not been documented in any comprehensive manner. The operation of juvenile collection and holding systems under high dissolved gas levels needs to be fully understood and documented

Recommendation: Provisions should be made to limit the holding of smolts to a maximum of 15 minutes (excluding anesthetizing time) before examination begins.

Recommendation: The operation of juvenile collection and holding systems under high dissolved gas levels needs to be fully understood and documented.

8.5 Physical Examinations

The monitoring program involves a variety of internal and external examinations of fish for signs of GBT. The examination approach consists of using internal and external signs of GBT which are believed to represent some prior history of exposure to DGS. Some of the external examinations involve non-microscopic visual procedures. Other facets of the program involves both microscopic external and internal examinations. Each procedure that was reviewed had procedural problems which could lead to invalid data. In other cases, it was clear that the particular examination was inconclusive and would probably remain inconclusive regardless of any modification which could be made. The problems identified with each physical monitoring procedure will be discussed in the following sections.

8.5.1 External Non-Microscopic Examination of Lateral Line, Body Surfaces and Fin Rays

Bubble formation in the lateral line, on external body surfaces, and in fin rays is a common sign of GBT in fish (Weitkamp and Katz 1980, Fidler 1988, White et al. 1991). In situations where dissolved gas levels are high and water depths are shallow, these signs are readily visible by simple visual examination. However, under these conditions fish are usually in a highly stressed state (Weitkamp and Katz 1980, White et *al.* 1991). It is clear that it is desirable to detect these signs long before the fish are in this state. The only way to effectively detect the early formation of bubbles in the lateral line, beneath external skin surfaces, and in the fin rays is under a microscope. Consequently, it is of little value to include any non-microscopic examination of fish for signs of GBT.

8.5.2 External Microscopic Examination of Lateral Line

This particular procedure is especially useful for early detection of the signs of GBT. However, it is prone to artifacts if the surface skin of the fish is allowed to warm to room temperature before the examination. Warming of the skin may cause any bubbles that are present to grow in size. This would result from the effects of Boyle's law and from reduced solubility of dissolved gases. Nuclei which are present may also start to grow. The solution to this problem is to make sure this examination is conducted quickly after the fish is removed from the water.

Just the opposite effects can occur if fish are held out of water for a long time before examination. Initially there may be bubbles present in the lateral line which may undergo additional growth as described above. However, because the partial pressure of nitrogen in air is less than that in blood, nitrogen will diffuse out of the bubbles and into the air. This will cause the bubble to collapse. As discussed in Section 8.4, the external examination of the lateral line should be conducted within 15 minutes after the fish is removed from the anesthetic solution.

8.5.3 Fish Anesthesia

At present, fish which are sacrificed for examination are killed with an overdose of an unbuffered solution of MS 222. The problem with this procedure is that unbuffered MS 222 acidifies the blood in the gill lamella. This, through the Root and Bohr effects, may drive oxygen off hemoglobin. This oxygen will supersaturate the plasma and raise the total dissolved gas pressure, which, in turn, may initiate bubble growth. The solution to this problem is to buffer the MS 222 to a pH of 7.5 with a mixture of 2 parts NaHC03 to 1 part MS 222.

Recommendation: Fish should be anesthetized in a buffered solution (pH = 7.5) of MS 222. This can be accomplished with a mixture of two parts NaHC03 to one part MS 222.

8.5.4 Internal Examination of Lateral Line

This examination involves peeling a section of skin along the lateral line to determine if bubbles are present beneath the skin surface. In practice, this was performed both under water and dry, and in most cases under some type of magnifying device (the McNary site was the only exception). However, it was found that bubbles are generated as an artifact from the process of peeling the skin from the underlying connective tissue and muscle. The review team documented the artifactual nature of these bubbles in test peels of the lateral line in chinook

salmon at the NBS Willard Field Station and in rainbow trout at Battelle in Richland. In steelhead, the procedure is further confounded since bubbles of real or artifactual origin may be retained beneath connective tissue covering the lateral line canal and may or may not be observed.

8.5.5 Excising of Gill Arch

Tbis procedure involves cutting one of the gill arches in the freshly killed fish underwater and examining for the presence of bubble emission in the blood expressed from the gill by vasculature pressure. It was the review team's conclusion that the observation of bubbles resulting from bleeding from the gills underwater without magnification is of no utility. The method is unquantifiable, subjective, and it is doubtful that even large quantities of gas bubbles could be observed by this method. Surface tension forces may also prevent any bnbbles from being removed from the gill tissue.

8.5.6 Microscopic Examination of Gill Lamella

This procedure involves cutting a segment of primary lamella from the gill arch and examining the segment under a compound microscope. This procedure has considerable value as a means of detecting bubbles in the afferent and efferent arteries of the primary lamella This is the location where bubbles in tbe vasculature are likely to first form. However, there are problems which can lead to artifacts. These involve the same considerations as were described above for bubbles in the lateral line. That is, heating of the primary lamella to room temperature may cause bubbles in the lamella to grow. On the other hand, if the lamella are held too long, the bubbles may disappear. As with the examination of the lateral line the examination of the gill primary lamella should be initiated no more than 15 minutes after the fish is removed from the anesthetic solution. It is recommended that the slide on which the lamella are placed should be at reservoir water temperature. Placing the sample slide on a glass block or a stack of slides cooled to reservoir water temperature would help stabilize the temperature of the gill lamella.

Recommendation: The first microscopic examination performed should be of the gill lamellae. As soon as each lamella sample has been removed, the fish should be returned to a bucket of water that is at the same temperature as reservoir water.

Primary lamellae from the gills should be excised by clipping the outer 3 to 5 mm of the lamellae tips from the gill arches. There is no need to cut out any gill arches. A numerical grading procedure should be developed for this type of examination. In addition, the appearance of gas bubbles which should result in a positive recording need to be presented in the form of photographs or diagrams for the monitoring operators.

The excised gill lamellae should be placed on a slide which has been cooled to the temperature of the reservoir water. A 1/4" thick glass block or an equivalent thickness of stacked slides should also be cooled to the temperature of the reservoir water. The glass block or stack of slides should be placed on the microscope bed first and the gill sample slide placed on top.

8.5.7 Examination of Visceral Cavity

In this procedure, the visceral cavity of the fish was opened and the surface of the intestine and the kidney were examined, and the swim bladder was assessed visually for overinflation.

The examination of the swim bladder for overinflation suffers from two fundamental faults. First, in fish larger than about 50 mm, the bladder may vent automatically (Shrimpton et *al.* 1990a,b). Thus, the exact relationship between swim bladder inflation and prior exposure to supersaturated gas conditions is not known. Furthermore, overinflation of the swim bladder is not a condition associated solely with dissolved gas supersaturation. Under normal water dissolved gas conditions, a fish must overinflate the swim bladder at the water surface if it is to be neutrally buoyant at depth (FidIer and Miller 1994). Thus, it is recommended that this procedure should be deleted from the GBT monitoring program

The use of bubbles associated with the kidney and the intestine are inconclusive because of the lack of a defined relationship to gas supersaturated conditions and the subjective nature of the examination. It is recommended that this procedure should be deleted from the GBT monitoring program.

Recommendation: The examination of the swimbladder for over-inflation, and examination for bubbles in the kidneys and intestine should be deleted from the monitoring program.

Recommendation: All external or internal examinations for gas bubble trauma which do not involve microscopic examination should be eliminated. With current available information, the monitoring program for gas bubble trauma should be limited to external examinations of the lateral line and fin rays of smolts using a compound microscope. A numerical grading procedure for signs should be developed for these two examinations

8.6 Field Data Recording

Based on the review team's examination, it appears that the recording of data at the various monitoring sites is, for the most part, adequate. At some sites, monitoring personnel reported high incidence of fungal infections on the external body surfaces of some animals. It may be that such fish are more prone to GBT and may show signs more readily than uninfected fish. It would be valuable to establish.3 there is a relationship between fish health and the occurrence of GBT signs. In future monitoring programs, the data recording sheets should contain data fields which score fish health and note the presence of obvious infections.

Recommendation: The field data sheets should be expanded to include fields for recording information on external signs of fungal infections, lesions, and abrasions.

9.0 EVALUATION OF ADULT MONITORING PROGRAM

9.1 Location of Sites

The four adult sampling sites give good coverage of the Lower Columbia and Snake rivers. There is little reason to add additional monitoring sites. The Three Mile Dam site on the Umatilla River should be fully integrated into the existing monitoring program.

9.2 Validity of Samples

The primary way adults can move up the Columbia and Snake River is up the adult fish ladders (a minor number of adults migrate through the navigation lock). It is believed that sampled fish are a representative sample of the overall population of hatchery or marked fish migrating up the Columbia and Snake rivers.

The statistical basis for the number of adults examined is unclear. While there are serious constraints on the number of fish or species that can be examined, the data requirements and sampling procedures should be better defined.

Recommendations: The adult monitoring program should be reviewed in terms of the data requirements and procedures which are needed to make the program statistically valid. This should include a report which clearly defines the data needs, statistical interpretations, and limitations.

9.3 Species/Origin of Fish

Only hatchery or marked fish were sampled. With the current status on Columbia and Snake river salmon, it is ulikely that sampling of wild adults will be permitted. There has been limited experimental work on the effects of gas supersaturtion on adult salmonids. It is not known if adult hatchery steelhead are more sensitive to gas supersaturation that the other salmonid species in the Columbia and Snake rivers.

Recommendations: Comparative studies should be conducted to establish the relative susceptibility of adult salmonid species in the Columbia and Snake rivers to gas bubble trauma. The results of these studies would serve to validate the monitoring based on hatchery steelhead. It is likely that this work may have to be conducted on hatchery fish obtained from outside the Columbia River Basin.

9.4 Holdings Procedures

The holding systems for adults at Bonneville, Ice Harbor, and Lower Granite dams were not designed for operation under high ΔP conditions. For example, at Ice Harbor Dam, the adults are held in forebay water for up to 6 hours. At a ΔP of 130%, this could prove lethal to adults held at Ice Harbor Dam.

Recommendations: The operation of adult collection and holding systems under conditions of high dissolved gas levels needs to be fully understood and documented. This problem appears to be especially critical at Ice Harbor Dam.

9.5 External and Internal Examination

The personnel at the monitoring sites are performing a thorough and careful examination of adult salmonids for external signs of GBT. If external signs had been present, they would have been observed and recorded. No internal examinations were performed.

The current monitoring program is not adequate to assess the impact of high dissolved gas pressures on adults. In the SMP, internal signs were found in fish without external signs. The same progression of signs is thought to occur in adults, although little hard information is available for adult chinook salmon. While internal examination is desirable from a *monitoring* perspective, *it* is certainly not desirable from a population basis. Because of the current status of salmon on the Columbia and Snake rivers, it is likely that the trapping, anesthetization, and physical examination of adults will come under careful review and further restrictions.

Recommendations: Better instrumentation (such as ultrasound methods) for the detection of external and internal bubbles in adult fish are needed. Ideally, these methods could be applied to free-swimming fish but hand-held units would be useful for detection of internal bubbles in anesthetized adults.

Adults are also observed as they pass through the fish ladders. The detection of external bubbles against a dark fin on au anesthetized adult requires careful examination; on a rapidly swimming adult it is difficult, especially if the water is murky. The observers have not been provided any criteria on what should be recorded as gas bubble trauma. While these observers are highly skilled, any observations of external clinical signs of gas bubble trauma in the ladders are very subjective and may vary significantly from observer to observer.

Recommendations: Until further information and training is provided, reporting external signs of gas bubble trauma from the ladder observations should be discontinued. The recording of information on the physical condition of the adults (injuries, head burns, fungus, etc.) should continue.

A lesion described as "head bums" has been reported at Lower Granite. This lesion has been described as a loss of skin (and underlying tissue) on the top of the head. The incidence of this lesion appears to be related to the spill flows. The study team did not see any examples of this lesion. Ms. Phyllis Barney (fish health specialist, U.S. Fish and Wildlife Service, Lower Columbia River Fish Health Center) has not personally seen this lesion.

While this lesion could be a clinical sign of gas bubble disease, it might also be a result of net damage or physical contact with hydraulic structures at the dams.

Recommendations: Until further information is available, "head burns" should not be classified as a clinical sign of gas bubble trauma. Since this lesion could be lethal to adults., additional research is needed to clearly identify the cause(s), development, and impact of this lesion.

9.6 Field Data Recording

No significant problems were found in data collection/recording procedures used at the sites.

10.0 EVALUATION OF RESIDENT FISH/INVERTEBRATE MONITORING PROGRAM

10.1 Location of Sites

The three resident fish/invertebrate sampling sites are below Ice Harbor, Priest Rapids, and Bonneville dams. The highest total gas pressures typically occur below Ice Harbor and Priest Rapids.

10.2 Validity of Samples

As with any in-river monitoring program, the disuibution of fish within the river is not uniform and fish must be caught where they occur. Sampling biases appear to be more serious below Ice Harbor Dam due to poor lateral mixing across the river. There is not a simple solution to this problem.

10.3 Species/Origin of Fish

The species caught are representative of those which occur in the river. A significant number of resident salmon fingerlings were caught below Priest Rapids and Bonneville dams.

10.4 Holding Procedures

No problems were found in holding procedures.

10.5 External and Internal Examination

The personnel are performing a thorough and careful examination for external signs of GBT.

10.6 Field Data Recording

No significant problems were found in data collection/recording procedures used at the sites.

Recommendations: The monitoring of resident fish/invertebrates is critical to fully understanding the impact of dissolved gas supersaturation on the overall ecosystem of the Columbia and Snake rivers and should continue.

11.0 EVALUATION OF DISSOLVED GAS MONITORING PROGRAM

In contrast to the biological monitoring program which started in 1994, the dissolved gas monitoring program has been operating for at least 25 years. This monitoring program will be evaluated in terms of the good laboratory practices discussed in Section 4.2.

11.1 Location of Sites

The location of the dissolved gas monitoring stations was presented in Table 6-1. *There* appears to be au adequate number of monitoring sites to characterize the dissolved gas levels in the Columbia and Snake rivers. The conversion of the manual tailrace sites to automatic sites will further increase the number of sites available on a real-time basis.

11.2 Standard Operating Procedures (Gas Equipment and System Operation)

No written information was provided to the study team on Standard Operating Procedures for the monitoring program or operation of the dissolved gas monitoring equipment. It is assumed that this information does not exist.

None of the equipment used on the Columbia and Snake rivers is in compliance with the only published standard method for determination of dissolved gas supersaturation (STANDARD METHODS, 1989). This method requires a daily calibration of the instrument. Daily calibration may not be needed for fixed stations, but the reasons for changed from an established standard need to be clearly documented.

11.3 Accuracy and Calibration

No written information was provided to the study team on accuracy of dissolved gas equipment, calibration procedures, and system performance. It is assumed that this information does not exist.

A small number of total gas pressure measuremerits were made during the site inspections. These measurements were used to evaluate the amount of degassing that occurred in the smolt and adult **systems.** No measurements were made to evaluate the accuracy of the dissolved gas monitoring program conducted by the Corps of Engineers. All conclusions in this section are based solely on examination of published data and therefore should be viewed as preliminary.

18.3.1 Daily Data Provided by Fish Passage Center

The daily data presented in "Daily Averages and Instantaneous High Total Dissolved Gas Supersaturation (%) at Upper and Middle Columbia Stations" (see Appendix D) was reviewed for missing data. Over the period of 5/11/94 to 6/12/94, 21% of the daily data was missing from this table.

11.3.2 Daily Data Provided by Fish Passage Center for Redundant Stations

There are four sites with redundant (duplicate) gas sensing units: Ice Harbor, McNary (South), The Dalles, and Warrendale. The data for these redundant sites was reviewed for the period of 5/11/94 to 6/12/94 (33 days) for missing data and Total Gas Pressures with > 3 percentage points from the reading at the primary stations. The amount of missing or invalid data for the four stations is summarized in Table 11.1. Over the period of 5/11/94 to 6/12/94, 24 to 82% of the data from the redundant stations was missing or invalid. The higher level of missing

Table 11.1

Comparison of Missing Data and Invalid Data Based on Redundant Dissolved Gas Instrumentation

Site	Missing (#)	> 3 percentage points (#)	Total Unusable Data (#)	Total Unusable Data (%)
Ice Harbor	18/33	0/33	18/33	24
McNary (South)	18/33	1/33	19/33	58
The Dalles	18/33	9/33	27/33	82
Warrendale	23/33	0/33	23/33	70

data for the redundant stations appears to be due to the fact that some of these redundant stations had just been installed prior to the start of the spill and that not all the redundant data may have been reported to the Fish Passage Center. Data reporting problems will be discussed in more detail in the following section.

If the data from both the primarily and redundant station are considered together, the amount of missing and invalid data is significantly reduced (Table 11.2) and ranges from 0 to 55%.

Table 11.2

Comparison of Missing Data and Invalid Data for the Four Stations Based on Primary and Redundant Dissolved Gas Instrumentation

Site	Missing (#)	> 3 percentage points (#)	Total Unusable Data (#)	Total Unusable Data (%)
Ice Harbor	0/33	0/33	0/33	0
McNary (South)	0/33	1/33	1/33	3
The Dalles	9/33	9/33	18/33	55
Warrendale	0/33	0/33	0/33	0

Table 11.3
Incidence of Missing and Invalid Data Based on Hourly Data for Seven Days[1]

Date	Total Gas Pressure Data				Partial Pressure Data			
	Missing Data	Invalid Data	Total	Percent	Missing Data	Invalid Data	Total	Percent
5/23/94	62	27	89	14	124	27	151	23
5/28/94	58	25	83	13	124	25	149	23
6/6/94	54	4	58	9	120	4	124	19
6/7/94	59	0	59	9	102	49	151	23
6/8/94	57	3	60	9	122	42	164	25
6/9/94	141	0	141	22	138	48	186	29
6/10/94	61	0	61	9	110	72	182	28
Average				12				24

1 Hood Park and Ice Harbor 3.2 mile (primary) do not have DO monitoring capability.

11.3.3 Hourly Values Provided by U.S. Army Corps of Engineers

Hourly output from the dissolved gas monitoring program was obtained from the North Pacific Division office of the U.S. Army Corps of Engineers for seven days. The data was reviewed for missing and invalid data (Table 11.3). Over this 7 day period, 12% of the total gas pressure and 24% of the oxygen data was unusable.

Some serious misunderstandings have occurred over the purpose of the redundant monitoring stations. From the COE's perspective, the redundant stations were installed to ensure coverage at critical stations. Therefore, as long as one of the two stations was on-line, the redundant information was not needed.

During the period of 5/28/94 to 6/11/94, only information from one of the two units was (primary or redundant station) reported to the Fish Passage Center. It appears that the unit with the highest total gas pressure was reported, although there does not appear to be any specific written criteria for the selection.

Others agencies considered the purpose of the redundant stations was to provide information on the precision of the whole monitoring program. Therefore, the lack of both the primary and redundant data was considered as withholding of data and was viewed with great suspicion.

11.4 QA/QC Procedures

No written information was provided to the study team on QA/QC Procedures It is assumed that this information does not exist.

There is a perception among some of the agencies involved with the biological monitoring for gas bubble trauma that the current dissolved gas monitoring program on the Columbia and Snake rivers is inadequate for providing accurate information for managing spill releases. This perception is based primarily on the following issues:

(1) The lack of Standard Operating Procedures for the dissolved gas monitoring equipment.

(2) The lack of Standard Operating Procedures for the overall monitoring program.

(3) The lack of calibration information and system performance data.

(4) The lack of a functioning QA/QC program.

(5) A significant amount of missing or invalid data (see Table 11.1 through 11.3).

(6) Withholding of data by the COE for the redundant stations during some of the spill period.

The study team feels that there are serious problems with the current monitoring program. Review of the hourly data for a seven day period showed that 24% of the DO data was invalid. Much of the remaining DO (partial pressure) data was significantly less than saturation. This is probably due to inadequate water velocity across the electrode face. While the DO data is not critical to.the gas monitoring program, the high percent of invalid data suggests that other more critical parameters may also be in error.

Recommendations: Information on the current level of accuracy and reliability of the dissolved gas monitoring program on the Columbia and Snake rivers is not available but may not be adequate for real-time management of the spill program. Upgrading of the equipment, an improved routine maintenance program, written protocols, and an QA/QC program may be needed. Input on potential changes is needed from the fisheries and regulatory agencies.

11.5 Data Distribution

The timely distribution of all the dissolved gas monitoring data is critical to the acceptance of the whole monitoring program by all the states, federal, and tribal agencies.

Recommendations: Formal policies on data reduction, quality assurance, and data distribution for the dissolved gas monitoring program must be developed and distributed to all the agencies. These policies must be followed.

AP rather than TGP(%) is the preferred method for the reporting of dissolved gas supersaturation (see Section 5.1). Current water quality criteria, standards, and regulations are written in terms of TGP(%). The conversion from TGP(%) to ΔP will require the cooperation and consultation between many tribal, state, and federal agencies.

Recommendations: Dissolved gas pressures should be reported in terms of AP rather than TGP(%).

12.0 EVALUATION OF DATA REDUCTION, QUALITY ASSURANCE, AND DATA DISTRIBUTION

The Fish Passage Center is responsible for collection, preparation, and initial distribution of the data from the Gas Bubble Trauma Monitoring Program. Data from the different sites and programs is transmitted daily to the Fish Passage Center.

12.1 Data Reduction

On a daily basis, the following data tables are prepared:

Cover Sheet and Abbreviations

Lower Columbia River Smolt Monitoring Program Gas Bubble Symptoms *(external clinical signs)*

Snake River Smolt Monitoring Program Gas Bubble Symptoms *(external clinical signs)*

Smolt Monitoring Program Gas Bubble Symptoms from Separator Samples *(external clinical signs)*

Smolt Monitoring Program Gas Bubble Symptoms - Lateral Line and Internal Symptoms - Juvenile Hatchery Steelhead *(external and internal clinical signs)*

NMFS Gas Bubble Symptom Monitoring at FGE Sites *(exrernal clinical signs)*

NMFS Gas Bubble Symptom River Reach Monitoring Resident Fish Monitoring *(external clinical signs)*

NMFS Gas Bubble Symptom Net Pen Studies *(external and internal clinical signs)*

NMFS Gas Bubble Symptom Monitoring at Traps - Adult Salmonids - *(external clinical signs)*

Total Gas Pressure - Daily Averages and Instantaneous Highs

Total Gas Pressure - Average of 12 highest Readings, 24 hour Averages, and Highest Reading

Total Gas Pressure - Tailwater Instantaneous from manually deployed Probes

Each table includes only the most current 7 to 10 days data. The complete data for each summary table is maintained on computer. The study team's assessment of the Fish Passage Center preparation of data summaries is that the procedures are correct and adequate for the purposes of most parties interested in the data. The original data sheets (on each fish examined) are available for review at the Fish Passage Center in Portland.

The study team heard concerns about inappropriate pooling of data from different observations.

This may have occurred after the data were distributed to other individual and agencies. The Fish Passage Center prepared a separate data summary tables for each separate type of observation.

12.2 Quality Assurance

A comparison between raw data sheets from the field and data summaries showed that there was the occasional discrepancy between the two. However, these were obvious typographical errors which were in most cases corrected in subsequent data summaries. Between different daily summary tables for dissolved gas levels, some inconsistencies were noted in how invalid data was flagged (* versus ---).

As discussed in Section 7.1.3, the incidence of GBT signs at McNary did not appear to be consistence with the other monitoring sites and with what we know about development of GBT. The basis for this anomaly is unknown at this time but could be related to the (a) impact of the confluence of the Snake and Columbia rivers on smolt distribution, (b) differences in procedures, or (c) operator bias. As the differences between McNary and the other sites persisted for weeks, these differences should have triggered a site inspection. Routine inspections (and perhaps unannounced random inspections) of the sites may be needed to ensure that data is being collected in an uniform and accurate manner.

Recommendations: A quality assurance (QA) program must be developed and implemented for the overall monitoring program including sampling, examination of fish, data collection and processing, and data reporting.

12.3 Data Distribution

The study team heard concerns about delays in the distribution of data. The data summaries presented in Appendix D are not what was provided to the agencies in real time. It was reported that the data summaries for the smolts collected directly from the separators was not distributed until June and the May data was not distributed at all. The study team was unable to clearly document the time history of what data was distributed and what data (if any) was not distributed. While there may be some differences of opinions of what actually happened, there is a perception by some agencies that Fish Passage Center was withholding data.

The timely distribution of all the monitoring data is critical to the acceptance of the whole monitoring program by all the states, federal, and tribal agencies. Currently, the data from this program is available to interested individuals and agencies on a daily basis (by fax or modem). The study team hopes that any potential problems with data distribution were a startup problem and will not occur in the future.

Recommendations: Formal policies on data reduction and data distribution must be developed and distributed to all the agencies. These policies must be followed.

12.4 Reporting of Results

This data is being used for real-time operational control of spill releases, but it may have other important historical uses. It is important to document the results from each year's monitoring program in a manner that this information will be available to interested people five or ten years from now.

Recommendation: The results from the various GBT and DGS monitoring programs should be published yearly and distributed to agencies and libraries for permanent archiving.

13 .O IMPLEMENTATION OF STUDY TEAM RECOMMENDATIONS

The development and implementation of a revised monitoring plan for 1995 will require considerable analysis, protocol development, agency coordination, agency review, agency approvals, and personnel training. There is not much time to accomplish the required tasks prior to May 1995.

The study team suggests the formation of a number of implementation teams for the 1995 monitoring program. These might include the following types of teams:

Table 13.1

Implementation Teams for the 1995 Monitoring Program

Team	Responsibility
Program Development	To develop the detailed sampling plan and protocols
Training	Training of staff and supervisors
QA/QC	Establish a quality assurance program and ensure that program is properly understood and implemented

Recommendation: A number of implementation teams should be formed quickly to develop and implement a revised monitoring program for 1995.

Consideration should be given to conducting experimental studies to define precisely and quantitatively the signs of GBT which result from graded sub-acute levels of gas supersaturation exposure and to define the relative susceptibilities of species and stocks of fish to GBT. These studies are needed to provide validation and calibration. The studies could include an evaluation of the susceptibility of affected fish to predation, disease resistance, and recovery from sub-acute levels of GBT. Importantly, the studies would result in a more meaningful and sensitive monitoring program and provide quantification to support standards for detection of GBT and interpretation of signs in terms of potential survival of smolts. This, in turn, would provide a more scientifically defensible basis for water management decisions. Such studies would also provide training material and monitoring standards for operators of monitoring programs.

The results of the smolt monitoring program should be integrated with the results of the dissolved gas monitoring program. This should include an analysis of fish transit times between reservoirs and assessments of the probable dissolved gas histories which fish have experienced during their movement down the Columbia and Snake rivers.

14.0 RECOMMENDATIONS AND CONCLUSIONS

Considering me speed at which the Gas Bubble Trauma Monitoring Program was implemented this year, the Fish Passage Center and cooperating Federal, State, and Tribal Agencies have been doing a incredible job. The following recommendations are made to help improve the Gas Bubble Trauma Monitoring Program. The recommendations and conclusions from the previous six sections are presented below:

14.1 Smolt Monitoring Program

14.1.1 Location of Sites

- The monitoring program should be expanded to include monitoring at Ice Harbor Darn and at sites in the mid-Columbia River.

14.1.2 Validity of Samples

- Fish samples should be collected from the forebay area of each monitoring site and compared to fish from the smolt bypass system for signs of gas bubble trauma. These samples would provide a comparison of the relative degrees of gas bubble trauma severity between the two samples.

- Fish samples should be collected downstream from the dam spillways of each monitoring site and compared to fish from the smolt bypass system for signs of gas bubble trauma. These samples would provide a comparison of the relative degrees of gas bubble trauma severity between the two samples.

14.1.3 Species/Origin of Fish

- Comparative studies should be conducted to establish the relative susceptibility of the different species and stocks of anadromous fish in the Columbia and Snake rivers to gas bubble trauma. The results of these studies would serve to validate the monitoring based on hatchery steelhead. Additional information on the migration characteristics of the different stocks (depth in water column, time of travel, length of travel, etc.) may be needed to fully assess the gas supersaturation risk to these different stocks as they migrate down the Columbia and Snake rivers.

- The fish in the major hatcheries on the Columbia and Snake drainages should be examined for signs of gas bubble trauma prior to release.

14.1.4 Holding Procedures

- Provisions should be made to limit the holding of smolts to a maximum of 15 minutes (excluding anesthetizing time) before examination for signs begins.

- The operation of juvenile collection and holding systems under high dissolved gas levels needs to be fully understood and documented.

14.1.5 Internal and External Examination

- The smolt monitoring program should be reviewed in terms of the data requirements and procedures which are needed to make the program statistically valid. This should include a report which clearly defines the data needs, statistical interpretations, and limitations.

- Recommendation: The examination of the swimbladder for over-inflation, and examination for bubbles in the kidneys and intestine should be deleted from the monitoring program.

- All external or internal examinations for gas bubble trauma which do not involve microscopic examination should be eliminated. With current available information, the monitoring program for gas bubble trauma should be limited to external examinations of the lateral line and fin rays of smolts using a compound microscope. A numerical grading procedure for signs should be developed for these two examinations.

- Fish should be anesthetized in a buffered solution (pH = 7.5) of MS 222. This can be accomplished with a mixture of two parts NaHC03 to one part MS 222.

- The first microscopic examination performed should be of the gill lamellae. As soon as each lamella sample has been removed, the fish should be returned to a bucket of water that is at the same temperature as reservoir water.

- Primary lamellae from the gills should be excised by clipping the outer 3 to 5 mm of the lamellae tips from the gill arches. There is no need to cut out any gill arches. A numerical grading procedure should be developed for this type of examination. In addition, the appearance of gas bubbles which should result in a positive recording need to be presented in the form of photographs or diagrams for the monitoring operators.

- The excised gill lamellae should be placed on a slide which has been cooled to the temperature of the reservoir water. A 1/4" thick glass block or an equivalent thickness of stacked slides should also be cooled to the temperature of the reservoir water. The glass block or stack of slides should be placed on the microscope bed first and the gill sample slide placed on top.

14.1.6 Field Data Recording

- The field data sheets should be expanded to include fields for recording information on external signs of fungal infections, lesions, and abrasions.

14.1.7 Fish Passage Center - Preparation of Data Summaries

- The database of the Fish Passage Center should be expanded to include fields for information on any external signs of fungal infections, lesions, and abrasions.

14.2 Adult Monitoring Program

- The adult monitoring program should be reviewed in terms of the data requirements and procedures which are needed to make the program statistically valid. This should include a report which clearly defines the data needs, statistical

interpretations, and limitations.

- Comparative studies should be conducted to establish the relative susceptibility of adult salmonid species in the Columbia and Snake rivers to gas bubble trauma. The results of these studies would serve to validate the monitoring based on hatchery steelhead. It is likely that this work may have to be conducted on hatchery fish obtained from outside the Columbia River Basin.

- The operation of adult collection and holding systems under conditions of high dissolved gas levels needs to be fully understood and documented. This problem appears to be especially critical at Ice Harbor Dam.

- Better instrumentation (such as ulnasound methods) for the detection of external and internal bubbles in adult fish are needed. Ideally, these methods could be applied to free-swimming fish but hand-held units would be useful for detection of internal bubbles in anesthetized adults.

- Until further information or training is provided, reporting external signs of gas bubble trauma from the ladder observations should be discontinued. The recording of information on the physical condition of the adults (injuries, head burns, fungus, etc.) should continue.

- Until further information is available, "head burns" should not be classified as a clinical sign of gas bubble trauma. Since this lesion could be lethal to adults, additional research is needed to clearly identify the cause(s), development, and impact of this lesion.

14.3 Resident Fish

- The monitoring of resident fish/invertebrates is critical to fully understanding the impact of dissolved gas supersaturation on the overall ecosystem of the Columbia and Snake rivers and should continue.

14.4 Dissolved Gas Monitoring

- Information on the current level of accuracy and reliability of the dissolved gas monitoring program on the Columbia and Snake rivers is not available but may not be adequate for real-time management of the spill program. Upgrading of the, equipment, an improved routine maintenance program, written protocols, and an QA/QC program may be needed. Input on potential changes is needed from the fisheries and regulatory agencies.

- Formal policies on data reduction, quality assurance, and data distribution for the dissolved gas monitoring program must be developed and distributed to all the agencies. These policies must be followed.

- Dissolved gas pressures should be reported in terms of ΔP rather than TGP(%).

14.5 Data Reduction, Quality Assurance, and Data Distribution

- Formal policies on data reduction and data distribution must be developed and distributed to all the agencies. These policies must be followed

- A quality assurance (QA) program must be developed and implemented for the

overall monitoring program including sampling, examination of fish, data collection and processing, and data reporting.

14.6 Reporting of Results

- The results from the various GBT and DGS monitoring programs should be published yearly and disiributed to agencies and libraries for permanent archiving.

14.7 Implementation

- A number of implementation teams should be formed quickly to develop and implement a revised monitoring program for 1995.

15.0 ACKNOWLEDGMENTS

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Ms. Michele DeHart, Fish Passage Center

The staff at the dams and monitoring sites who had to endure all of our questions

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APPENDIX A SITE INSPECTIONS FORMS

Comments

Total gas pressures were measured with a Sweeney Saturometer Model DS1-A. Since only a single unit was available, it was not possible to measure dissolved gas levels at all the sites on June 8 and 9, 1994, when the study team split up into two groups.

When it was not possible to measure the forebay gas levels, gas levels were obtained from the hourly values from the U.S. Corps of Engineers monitoring program.

Site: Bonneville Dam
Date: May 7, 1994
Liiestage: Smolts

Parameter	Value/Description
Collection System	Open channel to migrate trap
Sampling Location	Directly from the separator
Sampling Interval	Once an hour
Holding interval 24 hour sample Trap sample	 N/A Currently within 1 how, previously up to 4 hours
ΔP (mm Hg) Forebay Holding Tank Examination Tank	 66 22-26 27
External Examination (only)	100% of smolts are examined
Internal/External Examination	30 hatchery steelhead fish every other day
Comments	Fish killed in unbuffered anesthesia during previous visit. Fish killed by blow to head on this visit. Fish to be examined are left out of water between lateral line examination and gill filament examination. Gill filament removed from excised gill arch and placed on warm slide. A very careful and thorough examination for bubbles.

Site: Bonneville Dam
Date: May 7.1994
Lifestage: Adults

Parameter	Value/Description
Collection System	North side of Power House 1
Sampling Location	From existing adult sampling unit
Sampling Interval	As they arrive
Holding interval 24 hour sample Separator sample	 N/A Unknown
ΔP (mm Hg) Forebay Holding Tank Examination Tank	 66 Not measured Not me&red
External Examination (only)	Very careful and thorough examination
Internal/External Examination	None
Comments	

Site: John Day Dam
Date: May 7,1994
Lifestage: Smolt

Parameter	Value/ Description
Collection System	Air lift pump from a single gate well
Sampling Location	From the gatewell tank
Sampling Interval	Once an hour
Holding interval 24 hour sample Gatewell Tank	 N/A Up to an hour
ΔP (mm Hg) Forebay Holding Tank Examination Tank	 33 (USCOE) 77 (from the moveable tank) 30
External Examination (only)	100% of smolt are examined
Internal/External Examination	30 hatchery steelhead fish every other day
Comments	Fish killed in unbuffered MS222. Fish to be examined are left out of water between lateral line examination and gill filament examination. Gill filament removed from excised gill arch and placed on warm slide. Kidney examined before gill examination. A very careful and thorough examination for bubbles.

Site: Ice Harbor Dam
Date: May 8, 1994
Lifestage: Adults

Parameter	Value/Description
Collection System	Fish ladder
Sampling Location	Top of fish ladder Trap must be lifted up onto the dam and fish transferred to transport tank; fish are transported 2 miles up stream, examined, and released Holding water comes directly from the forebay
Sampling Interval	5 days a week; up to 6 hours/day
Holding interval 24 hour sample Trap	 N/A Up to 6 hours in trap; 30-60 minutes in transport tank
ΔP (mm Hg) Forebay Holding Tank Examination Tank	 43 (USCOE hourly data) 56 N/A
External Examination (only)	Collect up to 10% of the number of fish passing the previous day; do not examine wild fish
Inter&External Examination	None
Comments	Very careful and thorough examination

Site: Lower Monumental Dam
Date: May 9, 1994
Lifestage: Smolts

Parameter	Value/Description
CollectionSystem	Open channel to separator
Sampling Location	Diitly from separator
Sampling Interval	Twice daily
Holdulg Interval 24 hour sample Separator sample	 24 hours 2 hours or less
ΔP (mm Hg) Forebay Holding Tank Examination Tank	 2 - (USCOE hourly data) 29 20
External Examination (only)	100 smolts of each species are examined twice each day
Internal/ExternalExamination	15 hatchery steelhead are examined twice each day.
Comments	Fish killed with unboffered solution of MS222. Fish to be examined are left out of water between lateral line examination and gill filament examination. Gill lamella removed from excised gill arch and placed on warm slide. Lateral line peel performed under water. A very careful and thorough examination for bubbles.

Site: Little Goose Dam
Date: May 9, 1994
Lifestage: Smolts

Parameter	Value/Description
CollectSystem	Open channel to separator
Sampling Location	Directly from separator
Sampling Interval	Twice daily
Holding interval 24 hour sample Gatewell Tank	 24 hours 1.5 hours or less
ΔP (mm Hg) Forebay Holding Tank Examination Tank	 31 (USCOE hourly data) 15 15
External Examination (only)	100 smolts of each species are examined twice each day
Intemal/Extemal Examination	15 hatchery steelhead are examined twice a day.
Comments	Fish killed with unbuffered solution of MS222. Fish to be examined are left out of water between lateral line examination and gill filament examination. Gill primary lamella tips removed from excised gill arch and placed on warm slide. Lateral line peel performed under water. A very careful and thorough examination for bubbles.

Site: Lower Granite Dam
Date: May 9, 1994
Lifestage: Adults

Parameter	Value/Description
Collection System	Fish ladder; operated 8-16 hours/day depending on run size
Sampling Location	Trap at top of fish ladder; fish must be netted and lifted into MS-222 tank; trap is being replaced
Sampling Interval	Trap operated continuously
Holding interval 24 hour sample Trap	 N/A Variable, ranging from immediate to over-night holding
ΔP (mm Hg) Forebay Holding Tank Examination Tank	 -6 (USCOE hourly data) Not Available Not Available
External Examination (only)	None
Internal/External Examination	Examine all fish with coded wire tags
Comments	Fish killed with unbuffered solution of MS222. Fish to be examined are left out of water between lateral line examination and gill filament examination. Gill primary lamella tips removed from excised gill arch and placed on warm slide. Lateral line peel performed under water. A very careful and thorough examination for bubbles.

Site: McNary Dam
Date: May 10, 1994
Lifestage: Smolts

Parameter	Value/Description
Collection System	New smolt collection system
Sampling Location	From the collection tank for normal monitoring program From the separator for the GBT monitoring
sampling Interval	Fish for the GBT examination are collected twice a day
Holding interval 24 hour sample Separator sample	 Up to 24 hours 15-20 minutes; holding prior to examination may range from immediate to several hours
ΔP (mm Hg) Forebay Separator Examination Tank	 84 (USCOE hourly data) 39 38
External Examination (only)	Everyday; all fish from normal monitoring program
Internal/External Examination	50 hatchery steelhead fish for external examination every day 30 hatchery steelhead fish for internal examination every other day
Comments	Fish killed with unbuffered solution of MS222. Fish to be examined are left out of water between lateral line examination and gill filament examination. Gill primary lamella are removed from excised gill arch and placed on warm slide. Lateral line peel performed out of water without microscope. Data collection procedures differed from standard protocols.

APPENDIX B

MONITORING PLAN - NATIONAL MARINE FISHERIES SERVICE

Monitoring Plan

Northwest Region
7600 Sand Point Way N.E.'
BIN Cl5700 Bldg. 1
Seattle, Washington 99115

May 20, 2994

Mr. Michael Downs, Administrator
water Quality Division
tate of Oregon .
Department of Environmental Quality
811 SW Sixth Avenue
Portland, Oregon 97204

Mr. Michael T. LLewelyn
Water Quality Program Director
Washinton Department of Ecology
P.O. Box 47600
Olumpia, WA' 98504-7600

Dear Mr. Downs and Mr. LLewelyn:

Enclosed is the National Marine Fisheries Service's, revised Gas Bubble Disease Monitoring and Management Program Plan for the 1994 spring. This plan supersedes the previous plan sent to your respective offices on May 20 and May 26 and includes all revisions requested by your agencies and other interested parties.

In summary, these revisions include a shift of total dissolved gas management from farebay monitoring locations to tailrace monitoring locations, rationale for the five and two percent triggers, a mechanism for reducing gas levels by five percent increments if the spill reduction is warranted, the inclusion of Three Mile Dam, Umatilla River adult monitoring, and a synopsis of the reporting and decision making process including the. addition of a third party scientific review panel to review monitoring methods and results and a modification of the bi-weekly Operations Group meetings to conference calls and one Wednesday meeting.

The two points of contact for questions regarding the plan continue to be: Dr. Steve Grabowski, Northwest Fisheries Science center, Seattle, (206)860-3292, for technical aspects of the monitoring program and Gary Fredricks, Environmental and Technical Services Division, Portland, (503)230-5454, for issues regarding implementation of the management program.

Thank you for your cooperation and assistance in reviewing and inplementing this program. We look forward to working with your respective agencies on future water quality issues affecting anadromous fishery resources in Oregon and Washington rivers.

19 May 1994

NATIONAL MARINE FISEERIES SERVICE
GAS BUBBLE DISEASE MONITORING AND MANAGEMENT PROGRAM

1.0 Introduotion

A,special spill operation started, 12 May at Columbia and Snake River hydrapower projects and is to continue through 20 June 1994. Effects of spill willbevaluated in-season on a Dailyibasis. Conference calls will occur on Tuesdays and Thursdays each weak at 1:00 pm to discuss the effects of spill. These calls will include technical representatives from the National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (FWS), Oregon Department of Environmental Quality (DEQ), and Washington Department of Ecology (DOE), U.S. Army Corps of Engineers (COE), Bonneville Power Administration (BPA), and the state and tribal fishery agencies. At weekly meetings (Wednesday) or on an emergency basis, decisions to continue or adjust spill will be made by the Operations Group with the concurrence of the NMFS, DEQ and DOE. The decisians will be based on the results of biological and physical monitoring using the criteria described below.

The current management action calls for: 1) spill levels necessary to pass 80% of the daily average juvenile migrants through non-turbine routes (spill, bypass, and sluiceway) at Bonneville John Day, McNary, Lower Monumental, Little Goose,and Lower Granite Dams, and the previously agreed upon upper limits of 40% of average daily flow at The Dalles Dam and 25 kcfs at Ice Harbor Dam; and 2) dissolved gas levels up to, but not to exceed, 20% of saturation for total dissolved gas (TDG). The incidence of GBD in migrant salmonids and the maximum level of TDG measure? downstream from each hydroelectrio project will determine the necessity for adjusting spill levels.

2.0 Dissolved Gas Monitoring

The U.S. Army Corps of Engineers (COE) will be responsible for measuring and reporting concentrations of TDG, in water at about 22 locations on the Columbia and Snake Rivers as described in the Dissolved Gas Monitoring Plan of Action of the 1994 Fish Passage Plan, and referenced in NMFS's 1994-98 Federal Columbia River Hydrosystem Operation Biological Opinion. It is crucial that the monitoring instruments and telemetry equipment be maintained adequately and that the data be entered onto the Columbia River Operational Hydromet Management System (CROHMS)

system in a timely manner during this spill program. Dissolved gas monitoring instrumentation will be checked and calibrated regularly, as required.

2.1 Locations and Frequency of Monitoring

The U.S. Corps of Engineers, North Pacific Division has established dissolved gas monitoring sites at forebays of all mainstem Columbia and lower Snake River Dams. In addition there are monitoring systemsdownstream from Dworshak, Ice Harbor, Priest Rapids, and Bonneville Dams and at Warrendale, Oregon (River Mile (RM) 141), at Skamania, Washington (RM 141), at Washougal, Washington (RN 121), at Kalama, Washington (RM 75), and at Wauna, Oregon (RM 42). Additional monitors are located downstream from spillways at Lower Granite, Little Goose, Lower Monumental, and McNary Dams; data from these monitors must be down-loaded manually after 2-, 3-, or 4-day intervals. Also, intermittent monitoring is being conducted by COE personnel downstream from spillways at John Day, The Dalles, and Bonneville Dams (see Appendix A). Dissolved gas levels are recorded hourly.

2.2 Measurement Technique

Total dissolved gas concentrations in water will be measured using Common Sensing, Inc. "tensiometers," state of the art dissolved gas monitoring devices. Data from forebay monitoring stations are transmitted by satellite to the CROHMS database, Downloaded data from tailrace data loggers will be provided daily.

2.3 Quality Assurance/Quality/Control

The COE technical staff will evaluate daily dissolved gas measurements in relation to model expectations based on spill to total flow relationships developed through 28 years of data accumulation. Repair and replacement of monitoring instruments will be made within 48 hours of an identified need. The COE has a permanent staff and contractors dedicated to oversight and maintenance of the dissolved gas monitoring system

3.0 Biological Monitoring Program

The biological monitoring program will include assessments of the prevalence of signs of GBD in migrating juvenile and adult salmonids, and in resident biota.

Salmonid Monitoring

Juvenile salmonids will be routinely monitored for signs of GBD as part of the Smolt Monitoring Program (see Appendix B), in association with ongoing fish 'guidance efficiency (FGE) research

and in river reach and cage studies conducted by the NMFS. Adult salmon will be monitored for signs of GBD as they ascend fish ladders at selected Snake and Columbia River dams.

3.1.1 Smolt Monitoring Program

The Fish Passage Center (FPC) conducts a system-wide juvenile salmonid smolt monitoring program (SMP) on the Snake and Columbia rivers. The FPC is responsible for maintaining extensive historical and real-time data bases of' physical and biological data pertaining to the migration. Under the guidance of the FPC the SMP crews have incorporated an additional element and will conduct gas bubble disease monitoring at seven dams - Lower Granite, Little Goose, Lower Monumental,. Rock Island, McNary, John Day and Bonneville.

At Rock Island and Lower Granite Dam sampling for gas bubble disease evaluation is conductsd 3 times per week. All other sites conduct sampling daily, One hundred or more fish of each species are sampled at each project. At Lower Granite, Little Goose, Lower Monumental and McNary dams (collector dams) and Rock Island samples are collected over a 24 hour period for evaluatior each morning. Presently, an additional 100 hatchery chinook and 100 hatchery steelhead are collected as the fish egress from the bypass conduit, i.e. no holding prior to assessment. The samples are collected twice daily (12 hour increments) with 50 hatchery steelhead and 50 hatchery chinook collected in the morning; and the sample repeated in the evening. The crews will observe for externa1 signs of GBD.

At John Day Dam fish are sampled hourly from the gatewell via an airlift collector, and at Bonneville Dam fish are collected several times per hour via an inclined screen sampler lowered into the bypass channel. Fish observed for GBD are taker directly from these samples.

Presently, 30 hatchery steelhead (from the 100 fish sample) are being sacrificed on alternate days for microscopic evaluation. The SMP crews have been trained by U.S. Fish and Wildlife Service staff,

Monitoring of live fish will include assessment of external signs of GBD primarily subcutaneous dermal emphysema on each fin, opercula, eye, and within the buccal cavity.

A subsample of 30 hatchery released steelhead will be acrificed at Little Goose, Lower Monumental, McNary, John Day and Bonneville dams on alternate days for microscopic examination. As with live fish, external GBD signs will be documented, in addition to examination of the lateral line, under a dissecting microscope. Microscopic internal examinations will

include observations, of the lateral line, gill arches, gill filaments, heart, swim bladder, and kidneys.

3.1.2 Fish Guidance Efficiency Studies

ongoing research by NMFS to evaluate fish guidance, efficiencies Of turbine'intake screens provides the opportunity to obtain daily samples of juvenile salmonids for GBD assessment at Little Goose, McNary The Dalles, and Bonneville dams. On each evening that FGE r'esearcli is conducted, a sample of up to 100 fish of each salmonid species will be examined for external signs of GBD. A subsample of 10 fish per species will be anesthetized and examined under a dissecting microscope for presence of lateral line bubbles.

In addition, 10 fish of each species collected in fyke nets (only if fyke nets are used as a part of daily FGE research) will be examined for internal signs of GBD.

3.1.3 In Situ Holding Experiments

NMFSD researchers are holding juvenile chinook salmon in pens downstream from Ice Harbor and Bonneville Dams to study progression of GBD signs and mortality relative, to ambient concentrations of gas, and to provide supplementary data to the smolt Monitoring Program (see Appendix C).

At weekly intervals throughout the period of spill, groups 100 subyearling fall chinook salmon will be transported from Bonneville Hatchery to holding pens in the river below Ice Harbor and Bonneville Dams. These test fish are divided into three different groups. One is held in 4-m. deep pens allowing unrestricted vertical movement/another in cages with depth restricted to O-l m, and the third 'in cages with depth restricted to 2-3 m. At the end of 4-day holding periods, visual examinations are made for external signs of GBD, documenting the presence of bubbles on or in fins, opercula, eyes, and buccal cavity. Subsamples of 10 fish from each group are examined under a dissecting microscope to assess lateral line bubbles. Mortalities are necropsied to assess internal signs of GBD.

1.4 Adult Monitoring

Adult salmon migrating upstream will be sampled in the fish ladders at Bonneville, Ice Harbor, and Lower Granite Dams.

1.4.1 Bonneville Dam

The ongoing Pacific Salmon Treaty research on stock identification and scale pattern assessment for adult chinook and sockeye salmon conducted by the Columbia River Inter-Tribal Fish Commission has been extended to accommodate assessment for

effects of spill and high dissolved gas concentrations on adult salmonids (effective date 20 Way).

Evaluations will be conducted on adult salmonids entering the trap in the north shore fish ladder of Bonneville Dam. intercepted fish will be anesthetized and examined visually for external signs of GBD. Following recovery, fish will be release back to the fish ladder.

Sampling will be conducted on a 3 days per week basis, 6 to 8 hours per day. With the given sampling rate, the expectation is to intercept from 3.1 to 4.2% of the adult salmonids passing Bonneville Dam, with daily catches ranging from 30 to 90 fish.

3.1.4.2 Ice Harbor Dam

Sampling of adult migrant salmonids will be conducted using a trap in the south shore fish ladder. This trapping facility was originally intended for a radio-tracking study which has bee suspended due to low numbers of returning spring/summer chinook salmon. However, the trap can be used to make crucial observations on adult salmon regarding the prevalence of signs o GBD after they have migrated through the lower Columbia River an entered the Snake River. Subject to ESA permit modifications, i is anticipated that this sampling will begin 20 May.

Evaluations for GBD will be made by gross' observation through a window in the trap or, when necessary, by closer examination of anesthetized fish. It is unlikely that gross observations in the trap will provide the necessary resolution; therefore, based on researcher discretion, fish will be removed from the ladder in the trap transfer container, anesthetised, an closely examined for external signs of GBD. All fish handled i this manner will be transported approximately one-half mile upstream from the dam, allowed to recover and released.

Sampling will be conducted 5 days per week with a maximum sample of 24 fish per day or 10% of the fish passage count for Ice Harbor Dam on the previous day, whichever is lower. election criteria emphasis will be on smaller 2-ocean fish (generally 79 cm or smaller) and 3-ooean fish marked with ventral or adipose fin clip.

3.1.4.3 Three Mile Dam (Umatilla River)

As a part of ongoing trapping operations conducted by the Umatilla Tribe at Three Mile Dam, adult salmonids will be examined for external signs of GBD. Trapping at Three Mile Dam is conducted so that adult migrants can be enumerated and trucked above upstream diversion dams'. close examination of anesthetized adult salmonids will be possible during normal trapping and transportation operations.

Lower Granite Dam

As a part of ongoing transportation research, adult fish passing Lower are routineluy trapped, anesthetized, examined for marks and any gross physical conditions. For duration of the spill Program, trapped adult salmonids will anesthetized and examined for external signs of GBD. After recovery from the anesthetic, adults will be returned to the ladder to continue their migration. The trap is operated about hours per day and 7 days per week; overall sampling rate is about 10% of fish passing Lower Granite Dam.

Monitoring Resident Biota

River Sampling & In situ Holding

When spill is occurring, weekly surveys for prevalence of GBD in resident fish' and invertebrates will be conducted downstream from Priest Rapids, Ice Harbor, and Bonneville Dams.

Three or more sampling'sites will be monitored within each of the three river reaches; in the lower Snake River, mid-Columbia, and lower Columbia River. At each site, up to 100 individuals of each resident or non-salmonid species will be examined for-signs of GBD. In addition, from each weekly survey, up to 100 individuals of each resident or non-salmonid species will be held for 4 days in ambient river water with one-half of the individuals held in shallow pens and one-half in deep pens. Survival rates and GBD incidence of sampled individuals held in net pens in each river reach will be compared to prevalence of. GED observed in resident fish collected in-river.

3.2.2 Reservoir Sampling

3.2.2.1 Little Goose Reservoir Electrofishing.

Sampling to capture northern squawfish for radio-tracking downstream from Lower Granite Dam conducted by University of Idaho will be expanded to include evaluation of GBD signs of fish captured (pending ESA permit approval). Northern squawfish captured during intermittent sampling throughout May and June will be examined for external signs of GBD. Prevalence and severity of impacts will be evaluated.

3.2.2.2 John Day Reservoir Beach Seining

Resident fish sampled in John Day Reservoir for a limnological study of the effects of drawdown onreservoir ecology will be examined for signs of GBD. Sampling will be conducted bi-weekly through the spill season.

4.0 Reporting

Results of monitoring and research activities will be compiled daily by COE, FPC, and NMFS; FPC will compile the information into an agreed format and provide it to NMFS on a daily basis for official distribution to the Operations Group, DEQ, DOE and all other interested parties. This information will be distributed via FAX by NMFS prior to 4:00 pm each working day. included Will be 1) average and maximum TDG levels for forebay and tailraces of each mainstem dam and river locations downstream from Bonneville Dam, 2) sample size and incidence of external signs of GBD among juvenile and adult salmonids sampled at each dam and those collected in conjunction with other ongoing research, and 3) internal and lateral line data as they become available (fish are assessed for internal and lateral line signs very other day).

On Tuesdays and Thursdays of each week, a Spill Monitoring Review Group consisting of technical representatives of NMFS, USFWS, BPA, and COE will meet (via conference call) to review monitoring data, discuss interpretation of the data and make. recommendations regarding necessary changes in spill. The results of these reviews will be included as a memo attached to the NMFS Thursday daily report.

Action L e v e l s

Total Dissolved Gas Concentrations

Spill will be reduced at upriver dams when the 12 hour average TDG concentration exceeds 120% of saturation (or other established limit) in the tailrace of any Snake or Columbia River Dam. Average tailrace concentrations of dissolved gas will be calculated using the 12 highest hourly measurements per calendar day. The use of 12-hour averages,, rather than 24-hour averages, is an attempt to set a more conservative standard, and to relate he measured concentrations of dissolved gas to the 12-hour spill cycles. The monitoring locations were changed to the tailrace at the request of the state water quality agencies, despite NMFS concerns that tailrace measurements might not provide representative data. Measurement of dissolved gas concentration made in tailrace locations immediately downstream from a dam can be extremely variable, depending on their locations relative to the spillway or powerhouse. Biologically, the most useful measurement would be at a location after Powerhouse and spillway waters have mixed, since this is the "block" of water to which migrating fish are largely exposed. Since concentrations of dissolved gases remain relatively stable as a mass of water moves downstream through the reservoir of the next dam, NMFS position that the forebay measurement at that next dam should provide a representative value.

If signs of GBD warrant a change in spill and associated dissolved gas levels, tailrace gas level readings should be changed in increments determined by the spill Monitoring Review group. The COE will determine necessary initial spill adjustments through model predictions based on spill-to-total-flow relationships. Spill and gas levels can then be adjusted based on field data.

5.2 Prevalence of GBD

The volume of spilled water will be reduced at upriver dams when external signs of GBD exceed the following action 1evels: 5% in juvenile salmonids and/or 2% in adult salmonids at any location If at any time GBD detected through lateral line and internal examination exceeds the above action' levels at two consecutive projects in any daily sampling period, or any unusual or unexpected events occur which would negatively impact survival of migrant salmonids, spill levels at upstream projects will be reassessed by the Spill Monitoring Review Group described in section 4.0 above. The decision to alter spill, including the locations and magnitude of change, will be made by NMFS after discussion with the Spill Monitoring Review Group and the Operations Group, including the DEQ and DOE.

The 5% limit for external GBD signs is a determination based on the collective professional judgements of NMFS staff. It has been observed that in past NMFS studies significant mortality did not occur until external GBD signs, were evident in greater than 5 percent of the test animals. The NMFS staff, therefore, felt that a limit of 5% was conservative and would not result in significant direct mortality. due to GBD.

The 2% limit for exterior GBD signs on adult salmonids is based on a no-harm standard. Since sample rates at the various adult monitoring stations is not expected to exceed 50 fish, one fish exhibiting GBD signs would trigger a change in spill and associated dissolved gas levels (2% of 50).

6.0 Quality Assurance/Quality Control

NMFS will be responsible for oversight of the GBD monitoring program during the period of increased spill. Continuing assessment of the study design and monitoring program for GBD in migrating juvenile and adult salmonids, as well as in resident fish and invertebrate species, will be by the Operations Group, NMFS technical staff, and Dr. John Colt, an independent regianal expert in dissolved gas research. NMFS and FPC technical 'staff will routinely conduct on-site review of sampling and monitoring protocols. Any problem will be immediately corrected by NMFS, with participation from the cooperating agencies.

In addition, a panel of scientists in the field of dissolved gas research will he assembled by NMFS with concurrence of the cooperating agencies, These experts will be consulted on issues regarding quality and interpretation of the monitoring data and planning of future GBD research.

The COE technical staff will evaluate daily dissolved gas measurements in relation to model expectations based on spill-to-total-flow relationships developed through 28 years of data

APPENDIX C MONITORING INFORMATION - FISH PASSAGE CENTER

FISH PASSAGE CENTER

2501 S.W. FIRST AVE. • SUITE 230 • PORTLAND, OR 97ZOl-4752
PHONE (503) 230-4099 • FAX (503) 230-7559

MEMORANDUM

DATE: June 13, 1994

TO: FFAC

FROM: Michele DeHart

RE: Dissolved gas and gas bubble symptom data collection and distribution

The Fish Passage Center is serving as the central data repository for information collected on dissolved gas supersaturation and gas bubble trauma symptom observations in juvenile and adult fish in the Columbia River Basin. The bulk of this information is summarized daily and distributed to interested parties (see attachment 1). In addition, a descriptive report of lateral line and internal examination results is prepared'weekly (see attachment 2). This memo will describe each component of the data that is collected and reported: how it is collected, wbere it comes from, what the format is and how it is compiled.

Smolt Monitoring Program data

Three categories of information are collected at Smolt Monitoring Projects:

1. Regular inspection of a' portion of the daily sample for external evidence of Gas Bubble Trauma (GBT) is conducted at Lower Granite, Little Goose, Lower Monumental, McNary, John Day and Bonneville dams. See attachment 3 for a description of the protocol and a sample data sheet. This information is transmitted daily along with the daily sample data by modem to our JBM System/36 minicomputer (S/36) (see attachment 4 for a sample printout). The raw data sheets are faxed or mailed weekly. This type of sampling and data collection was also conducted in 1993.
2. As noted in the protocol (attachment 3), at Little Goose, Lower Monumental and McNary dams, samples are additionally taken at the separator. The data are recorded and transmitted identically to the regular external observation data, with the notation that the observations were from the separator sample.
3. The third component consists of microscopic examination and dissection every other day of 30 sacrificed hatchery steelhead at all monitoring sites mentioned in 1) with the exception of Lower Granite Darn. 1994 is the first year for tbis component. Attachment 5 describes the protocol and shows sample data sheets. Since this component is new and involved extra training and personnel, there have been inconsistencies as the protocol was being developed and revised. Attachment 6 contains reports on the training trips for Smolt Monitoring personnel. Attachment 7 describes some of the major developments as the sampling progressed. This information is transmitted as it is collected as described in attachment 8. The numbers are summarized three times a week and included with the daily report, and a detailed descriptive summary is compiled weekly, as mentioned above.

National Marine Fisheries Service (NMFS) data

There are four categories of data collected and sent to us by NMFS on a daily basis. Observations from fish collected for FGE studies, observations from fish captured in the river reaches below Priest Rapids, Ice Harbor and Bonneville dams, results. from the net pen studies in the same locations, and observations from adult trapping. All of this information except the net pen results are faxed to us daily (attachment 9); the net pen data are faxed separately (attachment 10). In addition, we have asked that those trapping adults on the mainstem Columbia and Snake report their observations to us directly (see attachment 11). Attachment 12 describes all ongoing adult trapping efforts.

Total Dissolved Gas (TDG) Saturation data

All dissolved gas data is collected and made available by the US Amry Corps of Engineers (Corps). Most dissolved gas monitoring data is transmitted directly via satellite to the Corps Reservoir Control Center (RCC) where it is put on a public access data system (the CROHMS system). We download this data daily via modem (see attachment 13 for a sample of the data format). This year the Corps installed redundant monitors at the downstream Ice Harbor, McNary-Oregon, The Dalles and Warrendale stations. Data from these stations has been intermittently available to us. There are several other stations that are not connected to this system and must be manually downloaded by the Corps Walla Walla district, who send the information to RCC, who then forwards the information to us. The manually downloaded stations are located in the tailwaters of Lower Granite, Little Goose, Lower Monumental and McNary dams (see attachment 14 for the data format). Also, the Corps is taking point readings with manually deployed probes below John Day, The Dalles and Bonneville dams (see attachment 15 for sample data). The station data is collected hourly. We compile the dam from the various sources and compute daily averages, daily maximums and averages of the twelve highest readings in each 24 hour period.

attachments

FISH PASSAGE CENTER

2501 S.W. FIRST AVE. • SUITE 230 • PORTLAND, OR 97201-4752
PHONE (503) 230-4099 FAX (503) 230-7559

MEMORANDUM

DATE: June 10, 1994

TO: Interested Parties

FROM: Michele DeHart, FPC

RE: Daily Dissolved Gas and Biological Monitoring Data - PLEASE NOTE:

Attached is the daily monitoring information. The following points should be considered in utiliiing this information. Please call if you have any questions regarding this information.

- The dissolved gas data from redundant sites is being collected on a daily basis by the COE. The COE has decided not to provide the data. The situation is being discussed.
- Several modifications of sampling technique have occurred which have been refleted in the incidence of bubbles; specifically, June 2 at Bonneville Dam and June 6 at John Day Darn.
- The external incidence of gas bubbles is documented on the basis of examination of a large number of fish at each site. The sample numbers are adequate to detect signs of GBT and most sites monitor more fish than required.
- The lateral line microscopic monitoring is conducted three times a week . A sample of 30 hatchery steelhead are sacrificed for the examination three times a week.' The lateral line is observed in a two step process, including an examination of the intact lateral line with a dissecting scope (lateral line external), and an examination of the lateral line after the skin is peeled back (lateral line internal).
- The lateral line microscopic and internal examinations record all symptoms. There is no indication of severity in this data. Thus far all symptoms are classified as minor, that is few bubbles.
- The lateral line bubbles are not indicative of direct mortality or morbidity. In addition, the relation of exhibited lateral line bubbles to nitrogen supersaturation is not clear. The National Marine Fisheries Service has convened a panel to assess this information.
- Samples of steelhead were sacrificed at Lower Granite Dam for microscopic sampling on June 1 and on May 27. Lower Granite Dam is upstream from the spill passage program. The dissolved gas standard of 110 % was exceeded on one hoar, on one day from May 18 through May 31. On both May 27 and June 1, 25% of the steelhead sampled showed signs of gas bubble trauma.
- The lateral line microscopic data does not seem to correlate with dissolved gas level or spill level. The lateral line symptoms may relate to the manner in which the fish are collected and sacrificed for examination.

Gas Bubble Symptom Monitoring Summary

Abbreviations:

HCH1 = Hatchery Yearling Chinook
WCH1 = Wild Yearling Chinook
CHO = Subyearling &nook
HST = Hatchery Steelhead
WST = Wild Steelhead
HSO = Hatchery Sockeye
wso = Wild Sockeye
co = Coho

Samp = Number of each species examined
Obs = Number of fish observed with gas bubble symptoms
% GBS = (# Obs / # Samp) × 100
% TDG = Percent Total Dissolved Gas saturation
Morts = Number of mortalities

NMFS Sampling Programs

Juvenile salmonid sampling at FGE projects:

Fish that are guided into the gateway at projects testing guidance devices are observed for external symptoms. A subsample of these fish are observed for gas bubbles in the lateral line. The occurrence of symptoms is expressed as a percent of the total number of fish observed.

River Reach sampling:

Salmonids are observed as described above. Nonsalmonids consist of resident fish.

Adult sampling

Adults are observed for external signs of gas bubble trauma at Lower Granite, Ice Harbor and Bonneville dams.

1994 Snake River Smolt Monitoring Program Gas Bubble Symptoms

		Lower Granite Dam			Little Goose Dam			Lower Monumental Dam		
Date	Species	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS
06/04	HCH1	0	90	0.0%	0	37	0.0%	0	14	0.0%
	WCHl	0	50	0.04%	0	10	0.0%	0	6	0.0%
	CHO	—	0		-	0	—	0	2	0.0%
	HST	0	266	0.0%	0	52	0.0%	0	58	0.0%
	WST	0	51	0.0%	0	2	0.0%	0	6	0.0%
	WSO	0	9	0.0%	0	9	0.0%	0	1	0.0%
	All Species	0	466	0.0%	0	110	0.0%	0	87	0.04%
06/05	HCHl	0	101	0.0%	0	24	0.0%	0	58	0.09%
	WCH1	0	65	0.0%	a	9	0.0%	0	15	0.09%
	CHO	—	0		0	4	0.0%	-	0	-
	HST	0	37d	0.0%	0	74	0.0%	0	72	0.0%
	WST	0	91	0.0%	0	12	0.0%	0	7	0.04%
	WSO	0	10	0.0%	0	5	0.0%	-	0	—
	All Species	0	638	0.0%	a	128	0.0%	a	152	0.09%
06/06	HCH1	0	62	0.0%	0	28	0.0%	0	64	0.09%
	WCH1	0	42	0.0%	0	9	0.0%	a	16	0.09%
	CHO	0	1	0.0%	—	0	—		0	—
	HST	0	233	0.0%	0	76	0.0%	0	98	0.09%
	WST	0	24	0.0%	0	5	0.0%	0	10	0.09%
	WSO	0	9	0.0%	—	0	—		0	—
	All Species	0	371	0.0%	0	118	0.0%	0	155	0.04%
06/07	HCH1	0	41	0.0%	0	27	0.0%	0	52	0.05%
	WCH1	0	51	0.0%	0	25	0.0%	0	13	0.09%
	CHO	—	0		—	0		0	3	0.04%
	HST	0	39	0.0%	0	35	0.0%	0	55	0.0%
	WST	0	15	0.0%	0	5	0.0%	0	10	0.04%
	WSO	0	13	0.0%	0	1	0.0%	0	1	0.04%
	All Species	0	159	0.0%	0	93	0.0%	0	134	0.0%
06/08	HCH1	0	44	0.0%	0	40	0.0%	0	34	0.0%
	WCH1	0	51	0.0%	0	23	0.0%	0	15	0.0%
	CHO	—	0	—	—	0	—	0	3	0.0%
	HST	0	100	0.0%	0	55	0.0%	0	39	0.0%
	WST	0	29	0.0%	0	7	0.0%	0	1	0.0%
	WSO	0	4	0.0%	0	5	0.0%	0	1	0.0%
	All Specie5	0	225	0.0%	0	130	0.0%	0	93	0.04%
06/09	HCH1	0	27	0.0%	0	42	0.0%			—
	WCH1	0	37	0.0%	0	42	0.0%			—
	CHO	—	0	—	0	4	0.0%			—
	HST	0	100	0.0%	0	75	0.0%			—
	WST	0	2.5	0.0%	0	5	0.0%			—
	WSO	0	4	0.0%	0	6	0.0%			
	All Species	0	193	0.0%	0	174	0.0%	0	0	—
06/10	HCH1	0	3	0.0%	0	44	0.0%			—
	WCH1	0	20	0.0%	0	24	0.0%			—
	CHO	0	1	0.0%		0	—			—
	HST	0	74	0.0%	0	100	0.0%			—
	WST	0	7	0.0%	0	6	0.0%			—
	WSO	0	1	0.0%	0	4	0.0%			—
	All Species	0	106	0.0%	0	178	0.0%	0	0	—

1994 Lower Columbia River Smolt Monitoring Program Gas Bubble Symptoms

		McNary Dam			John Day Dam			Bonneville Dam		
Date	Species	# Obs	#Samp	% GBS	# Obs	# Samp	% GBS	# Obs	# Samp	%
06/04	CH1	0	713	0.0%	0	129	0.0%	0	110	0.0%
	CHO	0	30	0.0%	0	4	0.0%	0	102	0.0%
	HST	0	289	0.0%	0	59	0.0%	0	44	0.0%
	WST	0	28	0.0%	0	8	0.0%	0	26	0.0%
	CO	0	3	0.0%	0	45	0.0%	0	118	0.0%
	HSO	0	2	0.0%	0	1	0.0%		0	—
	WSO	0	102	0.0%	0	61	0.0%	0	40	0.0%
	All Species	0	1,167	0.0%	0	307	0.0%	0	440	0.0%
06/05	CH1	0	476	0.0%	0	127	0.0%	0	83	0.0%
	CHO	0	31	0.0%	0	12	0.0%	0	104	0.0%
	HST	0	155	0.0%	0	82	0.0%	0	57	0.0%
	WST	0	14	0.0%	0	12	0.0%	0	19	0.0%
	CO	0	4	0.0%	0	49	0.0%	0	111	0.0%
	HSO	0	7	0.0%	0	1	0.0%		0	—
	WSO	0	132	0.0%	0	102	0.0%	0	41	0.0%
	All Species	0	819	0.0%	0	385	0.0%	0	415	0.0%
06/06	CH1	0	272	0.0%	0	140	0.0%	0	112	0.0%
	CHO	0	25	0.0%	0	8	0.0%	0	105	0.0%
	HST	0	112	0.0%	0	56	0.0%	0	75	0.0%
	WST	0	14	0.0%	0	14	0.0%	0	34	0.0%
	CO	0	3	0.0%	0	24	0.0%	0	136	0.0%
	HSO		0	—	—	0	—		0	—
	WSO	0	71	0.0%	0	23	0.0%	0	45	0.0%
	AU Species	0	497	0.0%	0	265	0.0%	0	507	0.0%
06/07	CH1	0	362	0.0%	0	116	0.0%	0	112	0.0%
	CHO	0	24	0.0%	0	22	0.0%	0	122	0.0%
	HST	0	204	0.0%	0	51	0.0%	0	48	0.0%
	WST	0	18	0.0%	0	6	0.0%	0	22	0.0%
	CO	0	4	0.0%	0	16	0.0%	0	106	0.0%
	HSO	0	10	0.0%	—	0	—	—	0	—
	WSO	0	78	0.0%	0	30	0.0%	0	37	0.0%
	AU Species	0	700	0.0%	0	241	0.0%	0	447	0.0%
06/08	CH1				0	156	0.0%	0	100	0.0%
	CHO				0	12	0.0%	0	100	0.0%
	HST				0	40	0.0%	0	47	0.0%
	WST				0	6	0.0%	0	19	0.0%
	CO				0	11	0.0%	0	110	0.0%
	HSO			—	—	0	—	0	1	0.0%
	WSO				0	62	0.0%	0	25	0.0%
	All Species	0	0	—	0	287	0.0%	0	402	0.0%
06/09	CH1	0	99	0.0%	0	107	0.0%	0	94	0.0%
	CHO	0	8	0.0%	0	11	0.0%	0	121	0.0%
	HST	0	253	0.0%	0	33	0.0%	0	44	0.0%
	WST	0	24	0.0%	0	11	0.0%	0	21	0.0%
	CO	0	2	0.0%	0	14	0.0%	0	100	0.0%
	HSO	0	3	0.0%	0	1	0.0%	0	1	0.0%
	WSO	0	27	0.0%	0	95	0.0%	0	22	0.0%
	AU Species	0	416	0.0%	0	272	0.0%	0	403	0.0%
06/10	CH1	0	472	0.0%	0	100	0.0%	0	108	0.0%
	CHO	0	15	0.0%	0	6	0.0%	0	103	0.0%
	HST	0	298	0.0%	0	25	0.0%	0	48	0.0%
	WST	0	27	0.0%	0	4	0.0%	0	30	0.0%
	CO	0	4	0.0%	0	6	0.0%	0	101	0.0%
	HSO	0	8	0.0%	0	2	0.0%	0	3	0.0%
	WSO	0	57	0.0%	0	51	0.0%	0	21	0.0%
	Au species	0	881	0.0%	0	194	0.0%	0	414	0.0%

1994 Smolt Monitoring Program Gas Bubble Symptoms from Separator Samples

		McNary Dam*			Little Goose Dam			Lower Monumental Dam		
Date	Species / Sample Time	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS
06/01	HCH1 AM	0	50		0	2		0	34	
	HCH1 PM	0	50		0	25		0	10	
	TOTAL	0	100	0.0%	0	27	0.0%	0	44	0.0%
	WCH1 AM				0	1		0	3	
	WCH1 PM				0	8		0	8	
	TOTAL	—	—	—	0	9	0.0%	0	11	0.0%
	HST AM	0	46		0	50		0	44	
	HST PM	0	45		0	60		0	20	
	TOTAL	0	91	0.0%	0	110	0.0%	0	64	0.0%
	WST AM	0	4		0	3		0	1	
	WST PM	0	5		0	5		0	7	
	TOTAL	0	9	0.0%	0	8	0.0%	0	8	0.0%
	GRAND TOTAL	**0**	**200**	**0.0%**	**0**	**154**	**0.0%**	**0**	**127**	**0.0%**
06/02	HCH1 AM	0	50		0	1		0	16	
	HCH1 PM	0	50		0	19		0	13	
	TOTAL	0	100	0.0%	0	20	0.0%	0	29	0.0%
	WCH1 AM				—	0		0	3	
	WCH1 PM				0	6		0	3	
	TOTAL	—	—	—	0	6	0.0%	0	6	0.0%
	HST AM	0	47		0	27		0	50	
	HST PM	0	45		0	12		0	23	
	TOTAL	0	92	0.0%	0	39	0.0%	0	73	0.0%
	WST AM	0	3		0	2		—	0	
	WST PM	0	5		0	2		0	2	
	TOTAL	0	8	0.0%	0	4	0.0%	0	2	0.0%
	GRAND TOTAL	**0**	**200**	**0.0%**	**0**	**69**	**0.0%**	**0**	**110**	**0.0%**
06/03	HCH1 AM	0	50		0	9		0	17	
	HCH1 PM	0	50		0	4		0	4	
	TOTAL	0	100	0.0%	0	13	0.0%	0	21	0.0%
	WCH1 AM				0	1		0	2	
	WCH1 PM				0	2		0	1	
	TOTAL	—	—	—	0	3	0.0%	0	3	0.0%
	HST AM	0	46		0	25		0	49	
	HST PM	1	45		0	13		0	17	
	TOTAL	1	91	1.1%	0	38	0.0%	0	66	0.0%
	WST AM	0	4		0	2		0	1	
	WST PM	0	5		—	0		0	3	
	TOTAL	0	9	0.0%	0	2	0.0%	0	4	0.0%
	GRAND TOTAL	**1**	**200**	**0.5%**	**0**	**56**	**0.0%**	**0**	**94**	**0.0%**
06/04	HCH1 AM	0	50		0	8		0	3	
	HCH1 PM	0	50		0	4		0	1	
	TOTAL	0	100	0.0%	0	12	0.0%	0	4	0.0%
	WCH1 AM				0	1		—	0	
	WCH1 PM				—	0		0	1	
	TOTAL	—	—	—	0	1	0.0%	0	1	0.0%
	HST AM	0	47		0	35		0	31	
	HST PM	0	44		0	4		0	15	
	TOTAL	0	91	0.0%	0	39	0.0%	0	46	0.0%
	WST AM	0	3		0	2		0	2	
	WST PM	0	6		0	1		—	0	
	TOTAL	0	9	0.0%	0	3	0.0%	0	2	0.0%
	GRAND TOTAL	**0**	**200**	**0.0%**	**0**	**55**	**0.0%**	**0**	**53**	**0.0%**

1994 Smolt Monitoring Program Gas Bubble Symptoms from Separator Samples

		McNary Dam*			Little Goose Dam			Lower Monumental Dam		
Date	Species / Sample Time	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS
06/05	HCH1 AM	0	50		0	6		0	41	
	HCH1 PM	0	50		0	26		0	7	
	TOTAL	0	100	0.0%	0	32	0.0%	0	48	0.0%
	WCH1 AM				0	1		0	9	
	WCH1 PM				0	8		0	2	
	TOTAL	—	—	—	0	9	0.0%	0	11	0.0%
	HST AM	0	48		0	49		0	46	
	HST PM	0	46		0	16		0	13	
	TOTAL	0	94	0.0%	0	65	0.0%	0	59	0.0%
	WST AM	0	2		0	6		0	4	
	WST PM	0	4		0	4		0	2	
	TOTAL	0	6	0.0%	0	10	0.0%	0	6	0.0%
	GRAND TOTAL	0	200	0.0%	0	116	0.0%	0	124	0.0%
06/06	HCH1 AM	0	50		0	6		0	25	
	HCH1 PM	0	50		0	11		0	8	
	TOTAL	0	100	0.0%	0	17	0.0%	0	33	0.0%
	WCH1 AM				0	3		0	4	
	WCH1 PM				0	5		0	8	
	TOTAL	—	—	—	0	8	0.0%	0	12	0.0%
	HST AM	0	46		0	20		0	23	
	HST PM	0	49		0	9		0	16	
	TOTAL	0	95	0.0%	0	29	0.0%	0	39	0.0%
	WST AM	0	4		0	1		0	2	
	WST PM	0	1		—	0		0	1	
	TOTAL	0	5	0.0%	0	1	0.0%	0	3	0.0%
	GRAND TOTAL	0	200	0.0%	0	55	0.0%	0	87	0.0%
06/07	HCH1 AM	0	50		0	13				
	HCH1 PM				0	2				
	TOTAL	0	50	0.0%	0	15	0.0%	0	0	—
	WCH1 AM				0	3				
	WCH1 PM				0	5				
	TOTAL	—	—	—	0	8	0.0%	0	0	—
	HST AM	0	48		0	18				
	HST PM				0	6				
	TOTAL	0	48	0.0%	0	24	0.0%	0	0	—
	WST AM	0	2		0	3				
	WST PM				0	1				
	TOTAL	0	2	0.0%	0	4	0.0%	0	0	—
	GRAND TOTAL	0	100	0.0%	0	51	0.0%	0	0	—

* Chinook not differentiated by rearing type at McNary Dam; all chinook tabulated in Hatchery category.

1994 NMFS Gas Bubble Symptom Monitoring at FGE sites - Juvenile Salmonids

		Little Goose Dam			McNary Dam			The Dalles Dam			Bonneville Dam		
Date	Species	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS
05/27	HCH1	0	533	0.0%	0	105	0.0%	0	100	0.0%			—
	WCH1			—			—			—			—
	CHO			—			—			—			—
	HST	0	205	0.0%	0	117	0.0%	0	100	0.0%			—
	WST			—			—			—			—
	WSO			—			—	0	20	0.0%			—
	COHO			—			—	0	40	0.0%			—
	All Species	**0**	**738**	**0.0%**	**0**	**222**	**0.0%**	**0**	**260**	**0.0%**	**0**	**0**	—
05/28	HCH1			—	0	107	0.0%			—			—
	WCH1			—			—			—			—
	CHO			—			—			—			—
	HST			—	0	100	0.0%			—			—
	WST			—			—			—			—
	WSO			—			—			—			—
	COHO			—			—			—			—
	All Species	**0**	**0**	—	**0**	**207**	**0.0%**	**0**	**0**	—	**0**	**0**	—
05/29	HCH1			—	0	101	0.0%			—			—
	WCH1			—			—			—			—
	CHO			—			—			—			—
	HST			—	0	138	0.0%			—			—
	WST			—			—			—			—
	WSO			—			—			—			—
	COHO			—			—			—			—
	All Species	**0**	**0**	—	**0**	**239**	**0.0%**	**0**	**0**	—	**0**	**0**	—
05/30	HCH1			—	0	119	0.0%			—			—
	WCH1			—			—			—			—
	CHO			—			—			—			—
	HST			—	0	125	0.0%			—			—
	WST			—			—			—			—
	WSO			—			—			—			—
	COHO			—			—			—			—
	All Species	**0**	**0**	—	**0**	**244**	**0.0%**	**0**	**0**	—	**0**	**0**	—
05/31	HCH1			—	0	100	0.0%			—			—
	WCH1			—			—			—			—
	CHO			—			—			—			—
	HST			—	2	99	2.0%			—			—
	WST			—			—			—			—
	WSO			—			—			—			—
	COHO			—			—			—			—
	All Species	**0**	**0**	—	**2**	**199**	**1.0%**	**0**	**0**	—	**0**	**0**	—
06/01	HCH1			—	0	103	0.0%			—			—
	WCH1			—			—			—			—
	CHO			—			—			—			—
	HST			—	0	100	0.0%			—			—
	WST			—			—			—			—
	WSO			—			—			—			—
	COHO			—			—			—			—
	All Species	**0**	**0**	—	**0**	**203**	**0.0%**	**0**	**0**	—	**0**	**0**	—
06/02	HCH1			—	0	102	0.0%			—			—
	WCH1			—			—			—			—
	CHO			—			—			—			—
	HST			—	0	100	0.0%			—			—
	WST			—			—			—			—
	WSO			—			—			—			—
	COHO			—			—			—			—
	All Species	**0**	**0**	—	**0**	**202**	**0.0%**	**0**	**0**	—	**0**	**0**	—

1994 NMFS Gas Bubble Symptom River Reach Monitoring - Juvenile Salmonids

Date	Species	Below Bonneville Dam # Obs	# Samp	% GBS	Below Ice Harbor Dam # Obs	# Samp	% GBS	Below Priest Rapids Dam # Obs	# Samp	% GBS
06/02	CH1			—			—			-
	WCH1			—			—			-
	CHO			—			—			-
	HST			—			—			-
	WST			—			—			-
	WSO			—			—			-
	COHO			—			—			-
	All Salmonids	0	0	—	0	0	—	0	1	-
	Nonsalmonids			—			—			—
06/03	CH1			—			—			-
	WCH1			—			—			-
	CHO			—			—			-
	HST			—	0	1	0.0%			-
	WST			—			—			-
	WSO			—			—			-
	COHO			—	0	1	0.0%			-
	All Salmonids	0	0	—	0	2	0.0%	0	0	-
	Nonsalmonids			—	0	102	0.0%			—
06/04	CH1			—			—	0	21	0.0%
	WCH1			—			—			-
	CHO			—			—	0	31	0.0%
	HST			—			—			—
	WST			—			—			-
	WSO			—			—			-
	COHO			—			—			-
	All Salmonids	0	0	—	0	0	—	0	52	0.0%
	Nonsalmonids			—			—			—
06/05	CH1						—			-
	WCH1						—			-
	CHO									-
	HST									-
	WST									-
	WSO									-
	COHO			—						-
	All Salmonids	0	0	—	0	0	I	0	0	-
	Nonsalmonids			—			—			—
06/06	CH1	0	8	0.0%			—			-
	WCH1			—			—			-
	CHO	0	20	0.0%			—			-
	HST						—			-
	WST						—			-
	WSO						—			-
	COHO	0	1	0.0%			—			-
	All Salmonids	0	29	0.0%	0	0	—	0	0	-
	Nonsalmonids	0	181	0.0%	1	291	0.3%			—
06/07	CH1	0	42	0.0%			—	0	70	0.0%
	WCH1						—			-
	CHO	0	4	0.0%			—	0	30	0.0%
	HST	0	2	0.0%			—			-
	WST						—			-
	WSO						—			-
	COHO	0	5	0.0%			—			-
	All Salmonids	0	53	0.0%	0	0	—	0	100	0.0%
	Nonsalmonids	0	77	0.0%			—	0	126	0.0%
06/08	CH1						—	0	63	0.0%
	WCH1						—			-
	CHO						—	0	37	0.0%
	HST						—			-
	WST						—			-
	WSO						—			-
	COHO			—			—			-
	All salmonids	0	0		0	0	—	0	100	0.0%
	Nonsalmonids						—	0	123	0.0%

1994 NMFS Gas Bubble Symptom Net Pen Studies - Hatchery Subyearling Chinook

Date		Below Bonneville Dam					Below Ice Harbor Dam					Below Priest Rapids Dam				
		% TDG	# Obs	# Samp	% GBS	Morts	% TDG	# Obs	# Samp	% GBS	Morts	% TDG	# Obs	# Samp	% GBS	Morts
5/9-13	TDG	117					122									
	Test		1	38	2.6%	0		17	56	30.4%	4				—	
	Control		0	20	0.0%	0		2	10	20.0%	1				—	
5/16-20	TDG	115					118									
	Test		0	30	0.0%	0		1	28	3.6%	2				—	
	Control		0	20	0.0%	0		0	12	0.0%	0				—	
5/23-27	TDG	116					118									
	Test		1	39	2.6%	0		3	8	37.5%	1				—	
	Control		1	18	5.6%	0		0	15	0.0%	0				—	
5/30-6/3	TDG						118									
	Test				—			3	54	5.6%	0				—	
	Control				—			0	20	0.0%					—	

1994 NMFS Gas Bubble Symptom Monitoring at Traps - Adult Salmonids

		Bonneville Dam			Ice Harbor Dam			Lower Granite Dam		
Date	Species	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS
06/02	Chinook			—	0	6	0.0%	0	2	0.0%
	Sockeye			—			—			—
	Steelhead			—			—			—
	All Species	0	0	—	0	6	0.0%	0	2	0.0%
06/03	Chinook	0	10	0.0%	0	5	0.0%	0	10	0.0%
	Sockeye			—			—			—
	Steelhead	0	5	0.0%			—			—
	All Species	0	15	0.0%	0	5	0.0%	0	10	0.0%
06/04	Chinook			—			—	0	7	0.0%
	Sockeye			—			—			—
	Steelhead			—			—			—
	All Species	0	0	—	0	0	—	0	7	0.0%
06/05	Chinook			—			—	0	6	0.0%
	Sockeye			—			—			—
	Steelhead			—			—			—
	All Species	0	0	—	0	0	—	0	6	0.0%
06/06	Chinook			—	0	3	0.0%	0	3	0.0%
	Sockeye			—			—			—
	Steelhead			—			—			—
	All Species	0	0	—	0	3	0.0%	0	3	0.0%
06/07	Chinook			—	0	3	0.0%	0	7	0.0%
	Sockeye			—			—			—
	Steelhead			—			—			—
	All Species	0	0	—	0	3	0.0%	0	7	0.0%
06/08	Chinook	0	25	0.0%	0	4	0.0%	0	10	0.0%
	Sockeye	0	2	0.0%			—			—
	Steelhead	0	15	0.0%			—			—
	All Species	0	42	0.0%	0	4	0.0%	0	10	0.0%

Daily Average and Instantaneous High Total Dissolved Gas Saturation (%) at Upper and Middle Columbia Stations

	Boundary Waters		Grand Coulec		Chief Joseph		Wells		Rocky Reach		Rock Island		Wanapum		Below Wanapum (4 mi)		Priest Rapids (2.4		Below Priest Rapids	
	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High
05/27	113	114	108	109	108	109	109	112	108	109	108	109	106	108	122	134	113	124	109	115
05/28	113	114	108	109	108	109	107	108	107	108	107	108	105	106	120	134	115	127	112	117
09/29	113	114	108	110	108	109	107	107	109	110	109	110	107	108	119	130	117	126	110	117
05/30	112	114	108	109	107	108	106	107	107	109	107	109	106	107	117	129	116	125	110	116
05/31	113	114	108	110	108	108	107	108	107	107	107	107	107	110	119	129	119	126	114	118
06/01	112	113	108	109	108	109	107	108	107	108	107	108	107	109	114	128	115	122	112	117
06/02	113	120	108	109	108	109	108	109	108	111	108	111	104	106	114	125	110	118	108	113
06/03	117	122	109	110	103	110	110	111	109	110	109	110	104	106	109	123	119	126	110	113
06/04	116	119	109	109	109	109	110	111	109	109	109	109	105	106	108	111	110	111	106	108
06/05	119	120	109	110	109	110	108	109	—	—	—	—	105	107	109	110	108	110	105	106
06/06	118	119	109	110	109	109	108	109	107	108	107	108	105	106	109	111	110	113	107	108
06/07	118	119	108	109	108	108	107	108	108	108	108	108	104	105	107	110	108	111	106	107
06/08	118	119	107	109	107	108	107	108	107	108	107	108	103	105	106	107	106	107	104	105
06/09	117	119	107	108	107	108	107	108	108	109	108	109	105	106	107	107	106	108	104	105

Daily Average and Instantaneous High Total Dissolved Gas Saturation (%) at Snake Basin Stations

	Dworshak		Lower Granite		Granite Tailrace		Almota (4 mi below LGR)		Little Goose		Little Goose Tailrace		Lower Monumental		Lower Monumental Tailrace		Below Ice Ice Hardor		Below Ice Harbor (3.6 mi)		Below Ice Harbor (redundant)		Hood Park Bridge	
Date	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High
05/27	115	120	106	107	111	119	112	120	110	111	114	116	115	116	116	118	113	115	121	122	119	119	114	115
05/28	101	103	104	105	109	114	109	116	110	110	110	112	113	114	113	115	113	113	121	127.	—	—	113	113
05/29	101	102	104	104	109	114	110	116	109	110	109	109	112	113	113	114	112	113	121	122	—	—	112	113
05/30	109	115	103	105	109	115	110	117	108	109	109	109	109	111	112	115	110	113	120	122	—	—	112	115
05/31	111	112	102	103	107	114	108	116	109	109	108	109	109	110	111	114	110	112	121	122	—	—	112	113
	110	111	100	101	108	115	108	116	107	108	107	108	107	108	111	115	104	109	121	122	—	—	112	113
	112	117	103	106	109	115	109	117	107	108	106	107	109	114	113	115	106	115	121	123	—	—	112	115
06/03	117	120	104	108	109	114	109	115	107	108	—	—	109	110	—	—	111	112	121	122	—	—	113	115
06/04	117	118	102	103	108	114	109	116	106	106	—	—	108	109	—	—	109	110	121	122	—	—	112	115
06/05	117	119	104	105	107	114	108	116	106	106	111	111	108	110	—	—	110	112	121	122	—	—	113	115
06/06	116	117	103	104	109	116	109	116	105	107	108	111	108	109	—	—	109	110	120	122	—	—	111	113
06/07	116	117	101	102	112	115	116	116	105	106	109	110	106	107	—	—	105	108	121	122	—	—	111	113
06/08	116	117	100	101	—	—	—	—	104	105	—	—	105	106	—	—	106	108	120	122	—	—	112	115
06/09	116	119	100	102	—	—	—	—	104	105	—	—	106	106	—	—	107	108	120	122	—	—	112	117

Daily Average and Intantaneous High Total Dissolved Gas Saturation (%) at Lower Columbia Stations

	McNary North		McNary South		McNary South (redundant)		McNary Tailrace		John Day		The Dalles		The Dalles (redundant)		Bonneville		Warrendale		Warrendale (redundant)		Skamania		Camas/ Washougal		Kalama		Wauna Mill	
Date	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High
05/27	110	115	111	116	115	115	115	123	—	—	106	108	103	103	106	109	111	113	113	113	113	117	103	107	110	111	107	108
05/28	112	114	112.	114	—	—	112	114	—	—	106	108	—	—	106	107	111	112	—	—	112	113	101	103	109	111	106	107
05/29	111	112	111	112	—	—	111	114	—	—	106	107	—	—	107	108	111	112	—	—	112	113	102	103	108	109	105	106
05/30	110	114	111	115	—	—	111	115	—	—	—	—	—	—	108	111	112	113	—	—	114	115	103	106	109	111	104	106
05/31	111	112	109	111	—	—	111	117'	104	104	—	—	—	—	110	112	112	113	—	—	115	117	102	104	110	110	105	107
06/01	109	110	109	111	—	—	112	116	103	104	—	—	—	—	IO8	111	112	113	—	—	113	114	109	115	108	110	103	105
06/02	111	115	111	114	—	—	114	117	105	107	—	—	—	—	108	110	112	113	—	—	113	114	112	113	110	112	104	105
06/03	113	118	111	113	—	—	—	—	106	106	—	—	—	—	109	110	113	114	—	—	114	115	112	115	111	112	104	105
06/04	114	116	114	117	—	—	—	—	104	104	—	—	—	—	108	109	112	113	—	—	114	115	112	114	110	111	103	104
06/05	113	115	114	117	—	—	—	—	104	104	—	—	—	—	109	110	II3	114	—	—	114	115	112	114	111	112	103	104
06/07	110	111	110	111	—	—	—	—	104	104	—	—	—	—	108	109	113	114	—	—	114	114	112	113	110	111	103	103
	108	109	108	109	—	—	—	—	104	104	—	—	—	—	106	107	II2	113	—	—	113	114	111	113	109	110	102	103
	106	107	107	110	—	—	—	—	103	104	106	108	—	—	106	108	112	113	—	—	113	114	112	115	109	111	102	103
06/09	108	109	109	114	—	—	—	—	104	104	106	108	—	—	108	110	113	114	—	—	114	116	112	116	111	113	103	104

Data provided by the Corps of Engineers. Tailrace gauges are manually downloaded by Walla Walla District and forwarded through the Reservoir Control Center. Data from all other stations are collected via the GOES satellite network.

1994 Total Dissolved Gas Saturation (%) - Forebay Statons (except Warrendale and Skamania)
Average of 12 highest readings, 24 hour Average, and Highest reading of 24 hour period

	Lower Granite			Little Goose			Lower Monumental			Ice Harbor			McNary North			McNary South			McNary South (redundant)		
Date	12h Avg	24h Avg	High	12 h Avg	24 h Avg	High	12 h Avg	24 h Avg	High	12 h Avg	24 h Avg	High	12 h Avg	24 h Avg	High	12 h Avg	24 h Avg	High	12h Avg	24h Avg	High
05/27	106	106	107	110	110	111	115	115	116	114	113	115	114	110	115	115	111	116	115	115	115
05/28	105	104	105	110	110	110	113	113	114	113	113	113	113	112	114	113	112	114	-----	---	---
05/29	104	104	104	110	109	110	113	112	113	113	112	113	112	111	112	112	111	112	---	---	---
05/30	104	103	105	109	108	109	110	109	111	111	110	113	111	110	114	113	111	115	---	---	---
05/31	102	102	103	109	109	109	109	109	110	111	110	112	112	111	112	110	109	111	---	---	---
06/01	101	100	101	107	107	108	108	107	108	109	104	109	110	109	110	110	109	111	---	---	---
06/02	104	103	106	107	107	108	110	109	114	112	106	115	113	111	115	112	111	114	---	---	---
06/03	105	104	108	107	107	108	110	109	110	111	111	112	116	113	118	112	111	113	---	---	---
06/04	103	102	103	106	106	106	108	108	109	110	109	110	115	114	116	116	114	117	---	---	---
06/05	104	104	105	106	106	106	108	108	110	111	110	112	114	113	115	115	114	117	---	---	---
06/06	103	103	104	106	105	107	108	108	109	109	109	110	110	110	111	110	110	111	---	---	---
06/07	102	101	102	106	105	106	106	106	107	107	105	108	108	108	109	108	108	109	---	---	---
06/08	101	100	101	105	104	105	105	105	106	107	106	108	106	106	107	108	107	110	---	---	---
06/09	100	100	102	104	104	105	106	106	106	107	107	108	108	108	109	113	109	114	---	---	---

	John			The Dalles			The Dalles (redundant)			Bonneville			Warrendale			Warrendale (redundant)			Skamania		
Date	12h Avg	24h Avg	High	12 h Avg	24 h Avg	High	12h Avg	24h Avg	High	12 h Avg	24 h Avg	High	12 h Avg	24 h Avg	High	12h Avg	24h Avg	High	12h Avg	24h Avg	High
05/27	---	---	---	107	106	108	103	103	103	107	106	109	112	111	113	113	113	113	115	113	117
05/28	---	---	---	107	106	108	---	---	---	107	106	107	112	111	112	---	---	---	**112**	**112**	113
05/29	---	---	---	106	106	107	---	---	---	107	107	108	112	111	112	---	---	---	113	112	113
05/30	---	---	---	---	---	---	---	---	---	109	108	111	113	112	113	---	---	---	114	114	115
05/31	104	104	104	---	---	---	---	---	---	111	110	112	113	112	113	---	---	---	115	115	117
06/01	103	103	104	---	---	---	---	---	---	109	108	111	113	112	113	---	---	---	114	113	114
06/02	106	105	107	---	---	---	---	---	---	109.	108	110	112	112	113	---	---	---	113	113	114
06/03	106	106	106	---	---	---	---	---	---	109	109	110	113	113	114	---	---	---	115	114	115
06/04	104	104	104	---	---	---	---	---	---	109	108	109	113	112	113	---	---	---	114	114	115
06/05	104	104	104	---	---	---	---	---	---	109	109	110	113	113	114	---	---	---	115	114	115
06/06	104	104	104	---	---	---	---	---	---	108	108	109	113	113	114	---	---	---	114	114	114
06/07	104	104	104	---	---	---	---	---	---	107	106	107	112	112	113	---	---	---	114	113	114
06/08	104	103	104	106	106	108	---	---	---	107	106	108	112	112	113	---	---	---	113	113	114
06/09	104	104	104	107	106	108	---	---	---	109	108	110	114	113	114	---	---	---	115	114	116

Tailwater Instantaneous Total Dissolved Gas Saturation fmm manually deployed probes

Data collected by the Corns of Engineers

Date	Below John Day Dam		Below The Dalles Dam		Below Bonneville Dam (Hamilton)	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
05/16/94	112%	110%	—	—	—	—
05/17/94	—	—	116%	110%	—	
05/18/94	110%	108%	113%	109%	—	—
05119194	115%	110%	115%	114%	—	—
05/20/94	114%	113%	114%	112%		—
05/21/94	107%	105%	116%	112%	—	—
05/22/94	108%	105%	—	—	—	—
05/23/94	—	—	—	—	—	—
05/24/94	—	—	—	—	—	—
05/25/94	—	—	—	—	—	—
05/26/94	—	—	—	—	—	—
05/27/94	110%	107%	114%	113%	—	
05/28/94	112%	108%	116%	113%	—	—
05/29/94	113%	108%	115%	114%	—	—
05/30/94	115%	110%	114%	113%	—	—
05/31/94	122%	107%	115%	114%	—	—
06/01/94	110%	106%	—	—	111%	111%
06/02/94	113%	105%	—	—	111%	111%
06/03/94	—	—	—	—	112%	111%
06/04/94	118%	107%	114%	113%	—	—
06/05/94	—	—	—	—	111%	110%
06/06/94	123%	107%	114%	113%	113%	111%
06/07/94	114%	106%	115%	112%	112%	109%
06/08/94	114%	106%	113%	113%	—	—

1994 Smolt Monitoring/ Program Gas Bubble Symptoms - Lateral Line and Internal Symptoms
Juvenile Hatchery Steelhead

Site	Daate	# Sampled	Lateral Line External	LateraLine Internal	Gill Filaments	Internal Symptoms	Total Affected
Little Goose Dam	5/28	30	0	0	6	0	5
	5/30	30	0	0	10	1	10
	6/01	30	0	0	4	1	4
	6/03	30	0	0	5	0	5
	6/05	28	0	0	3	1	4
	6/07	21	0	0	3	0	3
	6/09	18	0	0	2	2	4
Lower Monumental Dam	5/27	30	0	1	6	6	11
	5/29	30	0	0	10	6	11
	5/31	30	0	0	4	6	9
	6/02	30	0	0	4	6	8
	6/04	30	0	0	3	7	9
	6/06	30	0	0	3	6	8
	6/08	13	0	0	4	3	6
McNary Dam	5128	30	0	0	0	0	0
	5/30	30	0	a	0	1	1
	6/01	30	0	0	0	0	0
	6/03	30	0	0	0	0	0
	6/05	30	0	0	0	0	0
	6/07	30	0	0	0	0	0
	6/09	15	0	0	0	0	0
John Day Dam	5/29	30	0	24	7	0	24
	5/31	30	2	14	14	2	22
	6/02	30	2	4	8	2	14
	6/04	30	1	18	9	3	21
	6/06	30	4	24	12	0	27
	6/08	18	0	1	2	1	2
	6/10	30	3	20	5	2	22
Bonneville Dam	5/29	30	20	29	18	6	29
	5/31	30	19	30	25	4	30
	6/02	30	a	30	9	3	30
	6/04	30	2	26	13	11	27
	6/06	30	5	29	9	18	30
	6/08	30	3	26	18	9	29
	6/10	22	2	19	7	0	19

CC; LAB

FISH PASSAGE CENTER

2501 S.W. FIRST AVE. . SUITE 230 • PORTLAND, OR 97201-4752
PHONE (503) 2304099 . FAX (503) 230-7559

MEMORANDUM

DATE: June 8, 1994

TO: Internal Signs of GBT Discussion Group

FROM: Margaret Filardo

RE: Data collected June 2 - June 8

I am providing a detailed description of the GBT signs observed in the sacrificed hatchery steelhead. I will be prepared to discuss any additional data that is received prior to the conference call tomorrow morning. It should be noted that it is becoming increasingly more difficult to get the hatchery steelhead at the sites to conduct the observations. Some sites will be going to 15 fish per day and reporting the data every other day as a combined thirty fish sample.

Little Goose Dam

- 6/1 - No external or internal lateral line bubbles. 4/30 with gill filament bubbles, one fish with one bubble, one fish with more tbau 5 bubbles, one fish with more than 10 bubbles, one fish with more than 20 bubbles., 1/30 with bubbles on kidney.
- 6/3 - No external or internal lateral line bubbles. 5/28 with gill filament bubbles, on with one bubble, one with 2 bubbles, one with 5-10, one with 10-15 and one with 20-30 bubbles. No other signs of GBT.
- 6/5 - No external or internal lateral line bubbles. 3/30 with gill filament bubbles (small), 1/30 with large bubbles in intestine.
- 6/7 - No external or internal lateral line bubbles. 3/21 with gill filament bubbles, one with 3 bubbles, one with 25 bubbles, one with 50 bubbles.

Lower Monumental Dam

- 6/2 - No external lateral lime bubbles and no internal lateral line bubbles. 4/30 with gill filament bubbles, 1 fish with 1 bubble, one fish with two bubbles, one fish with 3 bubbles and one fish with 4 bubbles. 5/30 with distended swim bladders, 1/30 with bubbles on kidney.
- 6/4 - No external or internal Lateral line. 3/30 with gill filament bubbles, one fish with one bubble, one fish with 2 bubbles and one fish with 8 bubbles. 6/30 with distended swim bladder and 1/30 with bubbles on kidney.
- 6/6 - No external or internal lateral line bubbles. 3/30 with gill filament bubbles, two fish with one bubble, one fish with 3 bubbles. 6/30 with distended swim bladder, one additional fish had bubbles on kidney

Attachment 2

McNary Dam

6/2 - No signs observed.
6/4 - No signs observed.
6/6 - No signs observed.

John Day Dam

6/2 -- 2/20 with external lateral line bubbles (1 with two bubbles, 1 with many). 2/20 with internal lateral line bubbles (1 with 2 bubbles, 1 with 3-4 bubbles). 6/20 with l-5 bubbles in one filament.

6/4 - 1/30 with 1 lateral line external bubble: 18/30 with internal lateral line bubbles., This is coincident with a change in technique where the individual squeezes along the lateral lii forcing fluid out and bubbles are detected in fluid dripped on top of fish. The project leaser reported that in her opinion this technique yielded a significant over estimation in the number of bubbles. It was abandoned after the, 6/6 sample. 9/21 with gill filament bubbles ranging from few to many in one filament 3/21 with bubbles on the kidney.

6/6 - 4/30 with 2-5 external lateral line bubbles. 24/30 with internal lateral line bubbles. Again this sample used the "milking" technique. 12/30 gill filament bubbles, most 2-3 in one filament, one fish with 2-3 in each filament. No internal signs.

6/8 - partial sample, will complete on 6/9. 0/18 external lateral line, 1/18 internal lateral line (5 bubbles), 2/18 with gill filament bubbles, 1 with one bubble in one filament, one with 5% of filaments affected. 1/18 with kidney bubbles.,

Bonneville Dam

6/2 - No bubbles in tbe external lateral lime; All fish with some bubbles in internal lateral line. 9/30 with bubbles in gill filaments, most with 1 - 2 filaments with l-3 small bubbles, 2 fish with four filaments with several small bubbles. 3/30 with distended swim bladder.

6/4 - 2/30 with 1-5 small bubbles in exterior lateral line 26/30 with some small bubbles in internal lateral line. 13/30 with gill filament bubbles, most involved l-2 bubbles in l-2 filaments, one with three filaments with 4 small bubbles, and one with 5 small bubbles in 4 filaments. 6/30 with distended swim bladders and 5 with 2-5 kidney bubbles.

6/6 - 5/30 with external lateral line bubbles (2-6 small) and 29/30 with internal lateral lii bubbles. 9/30 with gill filament bubbles, most a small number in a few filaments, one fish with more than 50 bubbles in 5 filaments. 13/30 with distended swim bladders, 2 of these also had bubbles on kidney. An additional 2 with bubbles on kidney. No information on one fish. Total of 16/30 with internal signs (corrected from 6/6 distribution).

6/8 - 3/30 with external lateral line, few small bubbles. 26/30 with internal lateral line ranging from a few small to many small bubbles. 18/30 with gill filament bubbles, most reported as l-2 small bubbles in l-2 filaments only one fish reported with many bubbles in one filament. 9/30 with distended swim bladder.

Protocol for Sampling Fish for Gas Bubble Symptoms at All Sampling Sites

1. The sample will consist of 100 fish per species per day. This sample will be taken 3 days per week. This sample will be composed of the same fish as used to determine descaling rates, weights, etc. When gas bubble symptoms are noted, then sampling will be accomplished on a daily basis at all sampling sites until the diiolved gas levels and associated gas bubble symptoms (GBS) arc reduced to more normal levels.

2. When GBS first appear in the sample, a comparative sample will be taken at the separator of the following dams: Little Goose, Lower Monumental. and McNary A sample of 100 fish of yearling chinook and steelhead will be obtained each day. Fish should be captured via a sanctuary dip net and transferred to the fish facility for examinati on. Samples should be taken twice during the 24 hour day. The purpose of this activity is to determine if GBS dissipate with time spent in the sample tank or raceways.

3. Individual fish will be examined for GBS in/on the fins. head, and eyes. Generally, first appearance of GBS is in the caudal fin.

4. The five classifications of GBS will be recorded. These classifications are:

   1. No Evidence = gas bubbles are not present in any tin.
   2. < 50% in one fin = gas bubbles are observed in less than 50% of the surface of one tin.
   3. 3 50% in one fm = gas bubbles are observed in greater than 50% of the surface of one fin.
   4. Two or more Fii = gas bubbles are present in at least two of the fish's fins.
   5. Fin(s) + Head = gas bubbles are present in one or more of the fish's fin(s), plus the head area

5. The Sequence to follow when inspecting a fish is to: 1) Inspect the fm area first, if no evidence is noted then, proceed to the next fish: 2) If only one fin has gas bubbles present, determine if 50% of the fm has bubbles. and record in the c or > 50% column, and proceed to next fish; 3) If a fish was noted to have gas bubbles in two or more fins, then look at me head for signs of bubbles: if no bubbles are noted in the head, record as two or more fins and proceed to the next fish. If bubbles were noted in the head area; and, 4) record as Fin(s) + head; and proceed to next fish.

   We can look for progression of GBS in the fish by using this sequence. Generally the progression is from the caudal fm to the anal or dorsal fin, and finally in the last stages to the head area on the fish.

Tramning:

1. Training of sampling personnel on recognition of gas bubble symptoms incidence will be completed prior to the fish passage season by experienced/trained personnel.

Attachment 3

Reporting GBS incidence to Fish Passage Center:'

1. The sample season for GBS will be from April 15 through June 15 unless high flow conditions exist prior to, or after; the normal sampling dates. The Fii Passage Center, will inform the sampling sites of any change in this schedule.

2. On the individual sample days for GBS, the data should be sent to the FPC on the Smolt Monitoring Summaries. The information should be added to the Comment Section and include the number observed with symptoms and ,the number examined for each species, negative reports are also needed. The information should always be in this format: HCHI: x/y; WCH1: x/y; etc.

3. The individual tally sheets recording the GBS by species and categories, and appropriate comments should be mailed to the FPC on Friday of each week, and will be verified by FPC personnel on a weekly basis.

4. During the GBS monitoring season, the sites should indicate in the S/36 batch comments that either 1) there was no GBS monitoring, 2) there were no observations of GBS, or 3) what the GBS observations were.

FPC Reporting of GBS:

1. The FPC will report levels of GBS incidence in the FPC's Weekly Report that is mailed out each Friday to about 300 paarties in the Columbia River Basin.

2. The FPC will further request that severe cases of GBS (fin(s). + head) at individual projects be documented by photo.

Dissolved Gas Symptoms

Site,__________
Date__________ Batch #________

Species: ____________________ Sample Size: ____________

No Evidence	<50% in one fin	>50% in one fin	Two or more fins	Fin(s) + Head
Totals:				

Species: ____________________ Sample Size: ____________

No Evidence	<50% in one fin	>50% in one fin	Two or more fins	Fin(s) + Head
Totals:				

Species: ____________________ Sample Size: ____________

No Evidence	<50% in one tin	>50% in one fin	Two or more fins	Fin(s) + Head
Totals:				

Species: ____________________ Sar le Size: ____________

No Evidence	<50% in one fin	>50% in one fin	Two or more fins	Fin(s) + Head
Totals:				

LMN LOWER MONUMENTAL DAM BATCH # 94084

Batch #.....94084
Start Date/Time.....060994 1600 (MMDDYY HHMM)
Stop Date/Time.....061094 1600 (MMDDYY HWMM)
Sample Method Code.....GC
Sample Quality Code.....1
Number of Hours Sampled..... 24.0
Number Gatewe 1 ls Sampled..... 00
Sample Rate (timer setting)... .25000000
Avg. River Flow..... 37.00
Avg. Powerhouse(1)..... 26.10 Avg Powerhouse(2)... .oo
Avg. Spill..... 10.10
Detail comments: RIVER TEMP. 60.9 DEGREES
EXT: HCH-1 0/6; WCH-1 0/3; ST--H 0/24; ST-W O/l;
INT: 5/24 EXLL: 0/24 INLL: 0/24 GF: 3/24; INSY 2/24
SEP: HCH-1 0/33 WCH-1 0/8 HCH-0 0/0; WCH-0 0/2.
ST-H 0/60; ST-W 0/6. VI TAGS 1 LEFT. RED; 1 YELLOW
LEFT. 1 SUCKER.

gas bubble symptom monitoring data

HATCHERY TOTALS

	Chinook 1	Chinook' 0	Steelhead	Coho	Sockeye	Total
Collected	132	0	240	0	0	372
Bypassed	0	0	0	0	0	0
Trucked	0	0	0	0	0	0
Barged	243	0	501	0	0	744
Morts.		0	15	0	0	23
Sampled		0	60	0	0	93

WILD TOTALS

	Chinook 1	Chinook 0	Steelhead	Coho	Sockeye	Total
Collected	32	8	24	0	8	72
Bypassed	0	0	0	0	0	0
Trucked	0	0	0	0	0	0
Barged	70	1.2	64	0	12	158
Morts.	0	0	0	0	0	0
Sampled	8	2	6	0	2	18

SUMMARY TOTALS

	Chinook 1.	Chinook 0	Steelhead	Coho	Sockeye	Total
co L Lectecl	3.64	8	264	0	8	444
Bypassed	0	0	0	0	0	0
Trucked	0	0	0	0	0	0
Barged	313	12	565	0	12	902
Morts.	8	0	15	0	0	23
Samp Led	41	2	66	0	a	111

Attachment 4

FISH PASSAGE CENTER

2501 S.W. FIRST AVE. • SUITE 230 • PORTLAND, OR 97201-4752
PHONE (503) 2304099 • FAX (503) 230-7559

MEMORANDUM

DATE: May 11,1994

TO: Smolt Monitoring Prognogra Site Personnel

FROM: Michele DeHart

RE: Additionai monitoring associated with gas bubble trauma

As you are all probably aware, additional spill' is being provided this year to aid the juvenile migration. As part of this program. we have been asked to add an additional monitoring element into the gas bubble trauma monitoring that is now on-going. This element is designed to detect early symptoms of dissolved gas in fish. It will require sacrificing a number of fish. and the close examination of their gill filament and lateral line. Training and equipment will be provided at each site. The protocol chat will be used for training and implementation is attached. The implementation of this monitoring on an alternate day basis will be initiated when dissolved gas levels reach 120%. As of this time. we do not know how the determination of dissolved gas levels will be determined. There are on-going discussions between NMFS and the operators. Therefore. we cannot tell you when the additionai monitoring will begin. Be assured that we will notify each site with as much lead time as possible. The attached protocol has been reviewed and approved for implementation by the Fish Passage Advisory Commitree.

We will be providing you with a separate data sheet and advice as to how the data should be transmitted to the FPC prior IO implementation. If you have any additional questions. please contact Margaret Filardo at 2304286 or Larry Basham at 230-4287.

391-94.mi

Attachment 5

Gas Bubble Trauma Sympvtom Monitoring
Lateral Liae and Gill Filament

1. On an every other day basis - thirty hatchery steelhead from the dissolved gas tramna monitoring sample will be randomly chosen and sacrificed by over-anesthetizing the fish.

2. These fish will be part of that day's sample for dissolved gas trauma monitoring and will be included in the sample statistics. In addition, the thirty (total) fish will be observed in-depth for lateral lii and gill filament symptoms.

3. GILLS:

The gills should be examined first. Fit, hold the fish down under water and cut the gill arch. Gas bubbles may bubble up as the blood is released.

Take the fish from the water and clip a second gill arch, placing it on a slide. The size that we anticipate these fish to be will require that the individual filaments be removed from me arch with a scalpel, and then coverslipped with a drop or two of water for a wet mount examination Examine the filaments under a compound microscope for evidence of gas bubbles in the gill capillaries.

This examination is crucial. Don't confuse round bubbles that happened to be caught under the cover-slip for bubbles inside the blood vessels of the gills. You *must* focus up and down with the fine focus of the microscope to ensure that what you are looking at is tmly inside the blood vessel. The bubbles acmally inside will probably not be round, they will be elongated because they take on the shape of the gill capillaries themselves. Perfectly round bubbles should be discounted, as they are probably extraneous bubbles just caught under a filament or coverslip.

This technique will take some practices

LATERAL LINE:

This is by direct exam under the dissecting scope. Look for bubbles along the indentation of the lateral-line. If none are apparent, peel back the skin of the fish to look between me skin and the muscle bundles for bubbles that may be in the indentation where the bundles meet each other. Examine both sides of the fish.

This is also a good opportunity to examine the eyes more closely under the dissecting scope for bubbles which may not be apparent to the unaided eye.

INTERNAL EXAM:

The' fish can be opened carefully with a scalpel. Do not puncture too deeply into the fish as you are trying to preserve the swim bladder intact. As you open the fish, look for gas bubbles in the intestine, and see if the swim bladder is abnormally distended. This will take some practice in identifying. Once noted, the swim bladder can be tugged aside. and the surface of the kidney examined for visible bubbles under the membrane.

* Each site will be provided with a compound and binocular dissecting microscope to use for fish observation. Fish Passage Center Staff will arrange and provide training to Smolt monitoring Program crews. We request that at least two biologists from each site be made available for the training session.

FPC 5/18/94

Dissolved Gas Symptom Monitoring: Lateral line, gill and internal

Juvenile Hatchery Steelhead

Site: _____ Date: _____

Batch#: _____

	Lateral Line External Symptoms			Lateral Line Internal Symptoms			Gill Filament Symptoms			Internal Symptoms		
	No	Yes	Description	No	Yes	Description	No	Yes	Description	No	Yes	Description
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												

	Lateral Line External Symptoms			Lateral Line Internal Symptoms			Gill Filament Symptoms			Internal Symptoms		
	No	Yes	Description	No	Yes	Description	No	Yes	Description	No	Yes	Description
16												
17												
18												
19												
21												
22												
23												
24												
25												
26												
27												
28												
29												
30												
Total#												

Site: _____ Date: _____ Batch#: _____

FISH PASSAGE CENTER

2501 [illegible] AVE. • SUITE 230 • PORTLAND, OR 97201-4752
PHONE (503) 230-4099 . FAX (503) 230-7559

MEMORANDUM

DATE: May 25, 1994

TO: Files

FROM: Larry Basham . FPC

RE: Trip Memo - Gas Bubble Trauma Training for SMP Personnel.

On May 13. 16, and 17, I accompanied USFWS pathologists to several of the mainstem sampling sites for the purpose of conducting GBT training for SMP personnel. Phyliss Barney did the training at McNary John Day, and Bonneville dams, and Eric Pelton at Lower Monumental and Little Goose dams One dissecting and one compound microscope, and a dissecting were issued to each project. COE microscopes are being used at Lower Monumental and one compound scope at Little Goose.

The protocol developed for assessing gas bubble symptoms was used for teaching the procedures and methods to all personnel. The actual sampling was generally initiated the day after our training session. It was evident rhat the sampling procedures would require quite a lot of extra time for the biologists: I estimated that it would take at least 10 minutes per fish initiaily, witb the best perhaps of 5 minutes per fish (most likely with 2 people) as they became more proficient through time. The external look entailed checking the fish for presence of air bubbles in the fins, head area including the mouth and eyes. and later the lateral line. Our training oniy inciuded the internal sectioning of the skin. removing it from the lateral line and viewing the fish's lateral line under a scope. The internal examination inciuded the lateral line mentioned above. a section from the second gill arch (ends of gill filament: about 20 or so were spread on a microscope slide); examination of the swim bladder. intestine. and kidney (microscope not necessary for last three items).

The training of SMP personnel went somewhat like this: 1. the protocol was read and reviewed for each person: 2. Phyliss or Eric demonstrated the correct procedure to follow for the external and internal examination of the fish. We used hatchery steelhead obtained from the sampling facility; 3 the biologists or techs then repeated the procedures with tips from all onlookers: 4. the fish were examined to confirm the presence of bubbles at the various points of the exam.

We found no presence of air bubbles in the few fish at Bonneville. John Day, McNary, or Little Goose dams. but air embolisms were noted in all four fish autopsied at Lower Monumental Dam. The air embolisms were found in the lateral line, gill filaments, and kidney in some combination. i.e.. lateral line only, or lateral line + kidney, etc. The examination of each fish was time consuming and thorough but it appears to be the only way to adequately assess whether bubbles are present in the lateral line. gills, or internal organs. The fish are examined externally prior to the internal exam. All evidence of gas bubble symptoms are recorded and faxed to the FPC for storage and/or dissemination IO interested parties.

Attachment 6

I reviewed procedures for capturing fish with the WDFW and ODFW biologists. At Little Goose and Lower Monumental dams. COE techs will capture the fish from the perforated plate just prior to the separator and have them available for the state biologists just prior to their sampling each morning or evening. At McNary, John Day, and Bonneville, the federal or state personnel will capture the fish. One hundred chinook (hatchery or wild) and one hundred steelhead (hatchery or wild) would be examined on a daily basis for GBT symptoms. Every other day, 30 hatchery steelhead would be sacrificed for the internal examination (15 morning and 15 evening). These 30 fish are part of the 100 steelhead sampled for that day.

Supervisors at each site were concerned that with the additional time required to do thexse examinations; they would run into funding problems due to the overtime and lack of personnel to cover the extra work. I informed them that this work would be covered somehow by the federal agencies. They will work up budgets for the additional time required to do this gas bubble sampling. The additional time for the survival studies at LGS and LWN would also be partitioned out. Paul Wagner was adding biological techs for LWN and MCN to assist the biologist.

I believe that adequate training was provided for each sampling site by either Phyliss or Eric. Both answered questions on the sampling procedures, and Phyliss farther assisted personnel at Bonneville and John Day after she returned from her Colorado trip.

I will make site visits to observe sampling at the three lower river SMP projects in the near future

R1-57

UNITED STATES GOVERNMENT **FISH AND WILDLIFE SERVICE**

Memorandum

To : Assistaant Regional Director-AFF
Region 1, Portland OR

DATE : May 31, 1994

FROM : Project Leader, Lower Columbia River Fish Health Center
Underwood, WA

SUBJECT: Gas Bubble Disease Summary of Observations

Starting on May 12, this laboratory trained a total of 16 people at the various fish passage facilities at Little Goose, Lower Monumental, McNary John Day, and Bonneville dams to observe signs of Gas Bubble Disease in outmigrating steelhead smolts. What we covered was:

- Gas in the gill by 1) cutting the filament underwater to observe bubbles coming out and 2) microscopic examination of approximately 20 filaments for bubbles
- External lateral line exams with the dissecting microscope
- Internal lateral line exams under the dissecting scope by peeling the skin of the fish away from the musculture while observing the lateral line pocket.
- A gross internal exam looking at 1) overextended gas bladders, and 2) bubbles in the kidney or intestine

May 12 and 13 there were no signs of gas bubbles in fish examined at McNary, Bonneville and John Day. On May 16 during a training session at Little Goose, the first signs of bubbles were observed in the lateral line, with May 17 at Lower Monumental showing bubbles in some gill filaments and along the lateral line. May 18 at John Day and at Bonneville, bubbles were seen in the gill filaments of some fish, and in some lateral lines. At the lower dams these minor signs are continuing, May 26 fish examined at the Lewiston trap (at the confluence of the Snake and Clearwater) showed no bubbles, while 4 fish of 15 at Lower Granite dam showed signs (2 with overinflated swim bladders. 2 with internal lateral line bubbles).

My direct observations on various days at several sites are that these signs are minor ones of gas bubble disease. When bubbles are observed in the gill filaments, they are small, and have not completely blocked the gill eapillaries. The gill filaments above and below the bubbles are still healthy looking, and still receiving a blood supply. Most often there is only one bubble per filament, with only 2 instances where more than one bubble per filament were observed. The bubbles are all small.

The lateral line bubbles are also very small. They are difficult to observe through the skin. but when the skin is peeled back, they appeared in the pockets of the lateral line. When I observed bubbles in the lateral line, tbe number of bubbles per fish averaged 2, wirh the mast I observed per fish being 3.

The internal signs are the most subjective The swim bladder and kidney observations are the most likely to be overestimated and gas bladder distenation could even be caused by the process by which these fish are collected. Some of the swim bladders I saw were very over extended, but this observation will vary from person to person.

The fish being sampled are otherwise appearing healthy.

The extent of the bubbles seen in these fish is very small. The i mpact on the gills is minor,as good blood flow was observed above and below the bubbles on the individual filaments. The internalsigns have also been at a very minor level.

In hatchery fish my experience with these low levels of signs and small number and size of bubbles are that the fish can fully recover from these effects. These levels are not lethal to the fish. Once the levels of supersaturation in the water is reduced or eliminated, the fish begin to rid themselves of the bubbles.

Phyllis Barney

cc Brian **Brown, for distribution** to **Dailly Spill Report** list

CBLHB

FISH PASSAGE CENTER

2501 S.W. FIRST AVE. • SUITE 230 • PORTLAND, OR 97201-4752
PHONE (503) 230-4099 • FAX (503) 230-7559

MEMORANDUM

D A T E : June 6, 1994

TO: The Files

FROM: Margaret Filardo

RE: Monitoring for Internal signs of Gas Bubble Trauma (GBT)

On May 10, 1994 the FPC staff along with the state agencies and CRITFC met with NMFS staff (Brian Brown, Chris Ross and Gary Fredricks), and USFWS staff (Fred Olney) At this meeting it was agreed:

- the FPC would add an element to the existing SMP monitoring program to assess signs of GBT through examination of the lateral line;
- the lateral line monitoring would be an early warning sign of GBT, evaluation of the extent of GBT would be based on the monitoring of external signs of GBT in the fins, eyesandheadareas;
- the external monitoring for signs of GBT that had been conducted on a three day a week basis since March was changed to an every day basis.

With that agreement in place FPC consulted with Phyllis Barney, USFWS and:

- developed a protocol for monitoring;
- trained the crews at the SMP sites; and,
- initiated the sampling end data collection of GBT lateral line microscopic monitoring on:
  May 12 - Mcnary Dam;
  May 17 - John Day Dam;
  May 17 - Bonneville Dam:
  May 18 - Little Goose Dam;
  May 19 - Lower Monumental Dam.

In the early part of the microscopic monitoring it became apparent that the data on the lateral line and internal signs would be difficult to interpret and utilize On the evening of May 19, NMFS prepared a draft monitoring plan and provided to FPC and ODFW for review. It established the management criteria for GBT signs as follows:

Attachment 7

- the volume of water will be reduced when signs of GBD exceed 5 % in juvenile salmonids and/or 2% in adult salmonids at any location. The draft went on to say that unusual, or unexpected events would invoke a change in spill levels.,

On May 20 NMFS submitted the final monitoring program to DEQ and the criteria for management of the spill program was modified from the agreed upon version with the addition of the following statement relative to the internal monitoring;

- "If at any time GBD detected through internal examination exceeds the above action levels at two consecutive projects in any daily sampling period,..., spill level at upstream projects will be decreased to avoid detrimental impacts to fish."

Subsequent data collection has further increased doubt regarding the applicability and utility of the lateral line and internal signs of GBT monitoring., The interpretation of the data appears to be subjective and the collection of data can be affected by the methods of collection. Specifically:

- According to Phyllis Barney, USFWS (memo dated May 31.1994) "...The fish being sampled are otherwise appearing healthy. The extent of the bubbles seen in these fish is very small. The impact on the gills is minor as good blood flow was observed above and below the bubbles on the individual filaments. The internal signs have also been at a very minor level. In hatchery fish my experience with these very low levels of signs, and small number and size of bubbles are thatt the fish can fully recover from these effects. The levels are not lethal to the fish. Once the level of supersaturation is reduced or eliminated, the fish begin to rid themselves of the bubbles. "

- Samples taken at Lower Granite Dam on May 26 and June 2. indicate tbat 27% of the fish sampled exhibited similar signs of GBT. No spill occurred above Lower Granite except for Dworshak Dam, which is 74 miles above Lower Granite with 42 miles of free flowing river.

- The presence of the signs of GBT does not correlate with flow or spill.

- Changes in technique yield changes in the incidence of bubbles, e.g.,
  June 2, Bonneville Dam - beginning with this sample personnel changed from using a dry paper towel to hold the fish to a wet paper towel. The incidence of lateral lii bubbles decreased.
  To-date, McNary Dam - SMP personnel observe and dissect the lateral line under water, rather than in the air. Lateral line bubbles have not been observed.
  June 6, John Day Dam - Because of the difficulty in dissecting the lateral line to obtain a good view of bubbles an alternate procedure was recommended by USFWS. The lateral line is dissected and milked for bubbles with detection by pouriag water on top of the lateral line. The incidence of reported lateral line bubbles increased.

In conclusion, the interpretation of the existing data set regarding tbe internal monitoring signs of GBT appears to be subjective and premature. There is a high likelihood that the data set may contain artifacts of the methods used for the monitoring procedure. There has not been sufficient time elapsed between the initiation of a new procedure and protocol, and the alterarion and standardization of procedures.

FISH PASSAGE CENTER

2501 S.W. FIRST AVE. . SUITE 230 . PORTLAND, OR 97201-4752
PHONE (503) 230-4099 . FAX (503) 230-7559

MEMORANDUM

DATE: May 27, 1994

TO: Smolt Monitoring Pro-gram Crews

FROM: Margaret Filardo

RE: Gas Bubble Symptom Monitoring

Congratulations on a job well done. Thank you for staying with us while the program was developed. We realize that this additional monitoring task has been difficult for most of our crews. Your willingness to work with us is appreciated. The good news is that things have calmed down and the data are being distributed to all interested parties on a regular basis. The Fii Passage Center is serving as the central repository for all the data collected, and if anyone asks you for data. they can contact us. We need to do some housekeeping IO clear up some of the questions being asked over the past few weeks.

1. The data should continue to come to the Fish Passage Center as two or three separate reports from MCN. LWN & LGS only. In the cmments section include:

   a) External Symptoms: Continue to report in the comments as you have been doing. e.g. EXT: HCH1 x/sample: WCH1 x/sample. ETC.

   b) Internal Symproms: We have agreed to provide a compete listing of these dam as they come in. Therefore. you should be reporting in the comments: INT: TOTAL X/30: EXLL X130: INLL X/30: GF X130: INSY X/30. TOTAL is equal to the **total** number of fish affected with symptoms in this sample. In addition. we would like you to FAX your data sheets for the past week to the FPC every Wednesday morning. We will be summarizing a report for the federal fishery agencies regarding the severity of the symptoms noted. Keep good notes in the comments section on the data sheets. Attached you will find a leter from Earl Dawley regarding the monitoring being done at Bonneville Dam. His suggestions pertain to all the sites: please incorporate them into your routine.

   c) Separator Sample: At transportation sires. samples are being retrieved off the separator in addition IO the sample being taken from the sample rank. Continue with this activity until we notify you otherwise. Thii is to be reported separately in the comments in the following format: SEP: HCH1 x/SAMPLE: HST x/SAMPLE.

I hope this clears up some of the confusion regarding the reporting. If you have any further questions just contact me. Thanks again for an outstanding job on your part!

437-94.mf

Attachment 8

DAILY SUMMARY			1 JUNE 1994									
1994 SNAKE AND COLUMBIA RIVER GAS BUBBLE DISEASE MONITORING												
JUVENILE SALMONID SAMPLING AT FGE PROJECTS												
	LITTLE GOOSE DAM			MCNARY DAM			THE DALLES DAM			BONNEVILLE DAM		
	N	N w/GBD	% GBD	N	N w/GBD	% GBD	N	N w/GBD	% GBD	N	N w/GBD	% GBD
CHIN-1	FGE studies completed			103	0	0				FGE studies completed		
WCHIN-1	for the season									for the season		
CHIN-0												
HST				100	0	0						
WST												
WSO												
COHO												
TOTAL				203	0	0						
ADULT SAMPLING												
	BONNEVILLE DAM			ICE HARBOR DAM			LOWER GRANITE DAM			UMATILLA		
	N	N w/GBD	% GBD	N	N w/GBD	% GBD	N	N w/GBD	% GBD	N	N w/GBD	% GBD
CHINOOK	29	0	0	5	0	0	6	0	0	2	0	0
SOCKEYE												
STEELHEAD	15	0	0									
TOTAL	44	0	0	5	0	0	6	0	0	2	0	0
NMFS RIVER REACH SAMPLING - JUVENILE SALMONIDS												
	< BONNEVILLE			< ICE HARBOR			< PRIEST RAPIDS			JOHN DAY RESERVOIR		
	N	N w/GBD	% GBD	N	N w/GBD	% GBD	N	N w/GBD	% GBD	N	N w/GBD	% GBD
CHIN-1												
WCHIN-1												
CHIN-0												
HST												
WST												
WSO												
COHO												
TOTAL												
NONSALMONIDS							102	0	0			

Attachment 9

NET PEN STUDIES			1994 SNAKE AND COLUMBIA RIVER GAS BUBBLE DISEASE MONITORING						
	< BONNEVILLE DAM			< ICE HARBOR DAM			< PRIEST RAPIDS DAM		
DATE	~9-13 MAY 1994								
TDG % sat.									
	N	N w/GBD	N Morts	N	N w/GBD	N Morts	N	N w/GBD	N Morts
H CHIN-0	60	12	0	62	17	4			
NONSALMONIDS									
CONTROL PEN									
H CHIN-0	20	0	0	10	2	1			
NONSALMONIDS									
DATE	~16-20 MAY 1994								
TDG % sat.	~113-118			~118					
	N	N w/GBD	N Morts	N	N w/GBD	N Morts	N	N w/GBD	N Morts
H CHIN-0	30	0	0	67	1	2 **			
NONSALMONIDS									
CONTROL PEN									
H CHIN-0	20	0	0 *	12	0	0			
NONSALMONIDS									
	* Two fish unaccounted for; either escaped or undocumented mortality.								
	** 39 fish unaccounted for; either escaped or undocumented mortality.								
	Net pen has been relocated away from area of high water velocity.								

Attachment 10

/ FPAC

FISH PASSAGE CENTER

2501 S.W. FIRST AVE • SUITE 230 • PORTLAND, OR 97201-4752
PHONE (503) 230-4099 • FAX (503) 230-7559

MEMORANDUM

DATE: March 28, 1994

TO: FPAC

FROM: Larry Basham, FPC

RE: Mainstem Adult Trapping Facilities - Recording Gas Bubble Trauma symptoms. head or other wounds noted on handled fish.

During the 1993 adult fish migration on the Columbia River. fairly high levels of spill were prevalent at all mainstem dams in mid to late May. Dissolved gas levels ranged as high as 141% saturation in the Snake River. Head injuries were recorded by WDW fish counters at the fish counting windows and at trapping sites. Few injuries' of any type were noted at Bonneville Dam, increased injury rates at John Day Dam, and at Lower Granite Dam head injuries averaged about 9% of the total sample of adult salmon from mid-May through mid-July.

This year is not shaping up as a high flow year: however. high flow/spill conditions can sometimes prevail for short durations, as weather is not a controllable item. The FPAC recommended that an adult fish monitoring program be initiated or continued during 1994 at the mainstem trapping sites. and that records of fish condition be made available to the Fish Passage Center on a weekly basis. A standard reporting format should be used to record data from individual fish. A summary of sampled fish should be compiled weekly, and should be mailed or FAX'd to the FPC. The summary should include the following:

1. Sampling Dates for Week
2. Number of Fish Sampled Per Week
3. Number of Fish Rated Good to Excellent Condition
4. Number 'of Fish with Head Burns
5. Number of Fish with Gas 'Bubble Trauma Symptoms
6. Comments on Fish Condition or Adult Passage for the Week

Please observe the caudal. anal. and dorsal tin for presence of air embolisms. In addition. the roof of the mouth should be observed to assure no bubbles have settled in that area as well.

The attached data sheet can be duplicated and sent (fax preferred) to the FPC on Wednesday or Thursday of each week. Please call me at the Fish Passage Center. 503/230-4287, if you have questions regarding the information required for the weekly summary. Additional fish quality information can be sent with that listed above. but mainly, we are interested in monitoring adult fish for Gas Bubble Trauma. symptoms and presence of head burns which may or may not be related to Gas Bubble Trauma symptoms. Some of the information may be used for the FPC weekly report.

cc: Jeff Fryer, CRITFC
Jerry Harmon, NMFS
Ted Bjornn, U of I Fisheries Coop Unit

Attachment 11

WEEKLY SUMMARY 'OF ADULT FISH MONITORING FOR GAS BUBBLE SYMPTOMS AND BEAD BURNS

week of _____

Sample Dates	# Sampled	# Good Condition	# Head Burns	# GBD
Total				

1. Examine each fish for quality **and** condition. Total to be recorded under # Sampled.
2. Record fish under # **Good Cond.,** if there are no visible marks or injuries noted on fish.
3. Head burns would include all injuries from the top of the head (eye area) to the fleshy portion of the fish's back, and recorded under # **Head Burns. The** head will be scalped (skin removed) or attached in some cases. The head area may be exposed to the cartilege.
4. The tins should be examined for presence of air embolisms. then the head area (gill cover and eyes), and finally the roof of the mouth. If bubbles are found. record under # **GBD.**

FAX or mail weekly summary to:

Fish Passage Center
2501 **SW Fii Ave. Suite 230**
Portland. OR 97201.4752.
FAX #: (503) 230-755-P

CC: LAF

FISH PASSAGE CENTER

2501 S.W. FIRST AVE. SUITE 230. PORTLAND, OR 97201-4733
PHONE (503) 230-4099. FAX (503) 230-7559

MEMORANDUM

DATE: May 24, 1994

TO: Files

FROM: Larry Basham, FPC

RE: Gas Bubble Trauma (GBT) Symptoms - Adult Monitoring

I spoke with both Todd Kleist, WDFW, and Brian Ziierman, Umatilla Tribe, regarding adult sampling at fish counting site (Walla Walla District) and at Three Mile Dam on the Umatilla River. Todd also informed me that Rudy Ringe was examinin g fish at Ice Harbor Dam for the presence of gas bubble symptoms. The Bonneville and Lower Granite sites have been routinely operating this season. The following schedules are listed.

Bonneville Dam - CRITFC and ODFW are sampling fish (steelhead and chinook) for age, hatchery/wild, condition, and gas bubble symptoms on a three day per week regime, Monday, Wednesday, and Friday. We receive GBT information from Jeff Fryer.

Lower Granite Dam - The NMFS is sampling CWT fish at the trapping site for presence of GBT symptoms as well as for overall condition of the fish passing the project. We receive information from the trapping on a weekly basis (Wednesday).

Ice Harbor Dam - The U of I is sampling a portion of the fish passing the south fish ladder. I believe the total sampled to be 24 chinook or 10% of the previous day's fish count at the dam, whichever is less. This is an add-on to catch fish that might be exposed to higher levels of dissolved gas below Ice Harbor Dam. It appears that the levels stay near 117% saturated most of the day.

Umitilla (Three Mile Dam) - Brian Zimmerman indicated that they were capturing adult fish at the dam and are looking for gas bubble symptoms among other things. One hundred percent of the fish are sampled at the dam and hauled upstream for release depending on date and river flow. He said that they had one questionable looking fish that might have been impacted by GBT as the fish had liquid noted just posterior to the eyes. During today's sampling a similar symptom was observed in another fish, and it was determined that the injury was due to mechanical injury.

Fish Counting Facilities - Fish counters are looking for gas bubble trauma symptoms on a daily basis, and these are reported to the fish count supervisor. So far, reports have shown minimal suspected damage from gas bubble trauma; four or five fish were noted with scalped heads since May 12. Todd will later summaarize the dam for the Walla Walla District projects.

Attachment 12

TOTAL DISSOLVED GAS REPORT FOR BOUNDARY (Canadian International Boundary Waters)
starting at 0033 12 JUN 1994
for a continuation see reports 107 & 108

DATE	TIME	WA TM DEG F	BARD FRES	TD GAS FEES	GAS %	N2 PEES	O2 FRES	SPILL QS	TOT OR	NUMB. GATES
0612	0100	055.9	0726.0	0855.0	117.8	661.0.	131.0	000.0	108.6	000.0
0612	0200	055.c	0726.0	0857.0	118.0	660.0	191.0	000.0	079.0	000.0
0612	0300	055.2	0722.0	0837.0	115.9	64'3.0	183.0	000.0	076.3	000.0
0612	0400	055. 0	0725.0	0814.0	112.3	633.0	180.0	000.0	063.5	000.0
0612	0500	055.8	0726.0	0821.0	113.1	638.0	186.0	000.0	066.4	000.0
0612	0600	055.8	0726.0	0833.0	114.7	644.0	188.0	000.0	068.5	000.0
0612	0700	055.6	0726.0	0831.0	114.5	643.0	185.0	000.0	059.3	000.0
0612	0800	055.8	0725.0	0825.0	113.8	639.0	184.0	000.0	077.3	000.0
0612	0900	055.8	0724.0	0830.0	114.6	645.0	186.0	000.0	097.5	000.0
0612	1000	055.6	0725.0	0826.0	113.9	643.0	184.0	000.0	147.9	000.0
0612	1100	055.9	0725.0	0841.0	116.0	645.0	192.0	000.0	156.5	000.0
0612	1200	056.1	0725.0	0859.0	118.5	665.0	194.0	000.0	175.7	000.0
0612	1300	055.9	0724.0	0843.0	116.4	656.0	186.0	000.0	181.1	000.0
0612	1400	056.1	0720.0	0838.0	116.4	650.0	190.0	000.0	181.1	000.0
0612	1500	056.7	0724.0	0841.0	116.2	653.0	186.0	000.0	181.1	000.0
0612	1600	056.5	0721.0	0841.0	116.6	654.0	186.0	000.0	199.9	000.0
0612	1700	056.5	0720.0	0849.0	117.9	661.0	1'30.0	000.0	205.2	000.0
0612	1800	056.7	0721.0	0853.0	118.3	661.0	1'31.0	000.0	194.2	000.0
0612	1900	056.5	0721.0	0851.0	118.0	653.0	189.0	000.0	209.4	000.0
0612	2000	056.7	0721.0	0851.0	118.0	660.0	191.0	000.0	209.4	000.0
0612	2100	056.7	0721.0	0851.0	118.0	660.0	189.0	000.0	219.1	000.0
0612	2200	056.7	0720.0	0852.0	118.3	659.0	190.0	000.0	204.3	011.0
0612	2300	056.5	0720.0	0853.0	118.5	660.0	189.0	000.8	169.2	000.0
0613	000	05G.7	0719.0	0853.0	118.6	664.0	188.0	000.0	141.7	000.0
0613	0100	056.7	0719.0	0851.0	118.4	663.0	190.0	000.0	104.3	000.0

TOTAL DISSOLVED GAS REPORT FOR GRAND COULEE
starting at 0033 12 JUN 1934

DATE	TIME	WA TM DEG F	BARO PRES	TD GAS PRES	GAS %	N2 PRES	02 FRES	SPILL QS	TOT QR	NUMB GATES
0612	0100	055.8	0741.0	0804.0	108.5	642.0	179.0	000.0	108.6	000.0
0612	0200	055.2	0742.0	0804.0	108.4	643.0	173.0	000.0	079.0	000.0
0612	0300	055.2	0742.0	0803.0	108.2	637.0	170.0	000.0	076.3	000.0
0612	0400.	055.0	0739.0	0804.0	108.8	C48.0	170.0	000.0	063.5	000.0
0612	0500	055.0	0741.0	0804.0	108.5	630.0	180.0	000.0	066.4	000.0
0612	0600	054.9	0739.0	0805.0	108.9	653.0	163.0	000.0	068.5	000.0
0612	0700	054.7	0739.0	0808.0	109.3	637.0	174.0	000.0	059.3	000.0
0612	0800	054.5	0739.0	0811.0	109.7	632.0	183.0	000.0	077.3	000.0.
0612	0900	055.0	0737.0	0811.0	ilO.O	645.0	174.0	000.0	037.5	000.0
0612	1000	055.6	0737.0	0813.0	110.3	631.0	1'31.0	000.0	147.3	000.0
0612	1100	055.9	0738.0	0809.0	109.6	637.0	181.0	000.0	156.5	000.0
0612	1200	056.1	0738.0	0805.0	109.1	636.0	181.0	000.0	175.7	000.0
0612	1300	056.1	0738.0	0808.0	109.5	634.0	190.0	000.0	181.1	000.0
0612	1400	056.1	0738.0	0807.0	109.3	628.0	173.0	000.0	181.1	000.0
0612	1500	056.5	0738.0	0807.0	109.3	633.0	177.0	000.0	181.1	000.0
0612	1600	056.5	0737.0	0807.0	109.5	644.0	169.0	000.0	199.9	000.0
0612	1700	056.1	0738.0	0804.0	108.9	639.0	185.0	000.0	205.2	000.0
0612	1800	056.5	0738.0	0803.0	108.8	628.0	17'3.0	000.0	1'34.2	000.0
0612	1'300	056.1	0738.0	0805.0	109.1	637.0	180.0	000.0	209.4	000.0
0612	2000	056.1	0736.0	0804.0	109.2	636.0	173.0	000.0	209.4	000.0
0612	2100	055.9	0737.0	08B3.0	109.0	623.0	189.0	000.0	219.1	000.0
0612	2200	055.8	0736.0	0802.0	103.0	636.0	181.0	000.0	204.3	011.0
06'12	2300	055.2	0736.0	0800.0	108.7	637.0	174.0	OOO.B	169.2	000.0
0613	000	055.2	0733.0	0802.0	109.4	636.0	170.0	000.0	141.7	000.0
0613	0100	055.0	0732.0	0802.0	103.6	631.0	178.0	000.0	104.3	000.0

Attachment 13

LG 1
Balcony T.
To: John Athearn
From: Tom Miller
07 Jan 94
1040 h

Attachment 14

DATE	TW TIME	FB TEMP	TW TEMP	FB BAR	FB TDG	TW TDG	FB %SAT	TW %SAT	DIFF %SAT	FB GSPILL	FB DIGITAL	FB %SPILL
027												

LITTLE GOOSE TOTAL DISSOLVED GAS DATA 1994 LG07JN94.WK1
TAILWATERS SHORE STATION (APPROX. 0.8 mi. DOWNSTREAM ON RIGHT BANK)

Analog Voltage Logging Module
Serial Number : 1885
Extracted : 06/07/94 09:35:58
Logger Started: 06/05/94 21:37:25
Logging Rate : 01:00:00
User Notes
new probe installed -- old one reading approx 30 mm low
-- now one fully calibrated

Coefficients
-303.89899 -275.15003 b0
0.37400 0.12210 b1
0.00000 0.00000 b2
0.00000 0.00000 b3
0.00000 0.00000 b4
0.00000 0.00000 b5

NOTE: TW=BASED ON DATA FROM HYNET LOGGER;FB=CAME FROM MPD (SUTRON ECT.); CPS=CAME FROM CONTROL ROOM LG
FB TIME=SAME HOUR AS TW REGARDLESS ON IN MINUTES
TW BAR = 750 throughout BASED ON PORTABLES

DATE	TW TIME	FB TEMP	TW TEMP	FB BAR	FB TDG	TW TDG	FB %SAT	TW %SAT	DIFF %SAT	FB GSPILL	FB GTOTAL	FB %SPILL
6 6 94	10 37 25		14.1			793.0		105.7				
6 6 94	11 37 25		14.1			793.0		105.7				
6 6 94	12 37 25		14.2			793.8		105.8				
6 6 94	13 37 25		14.2			793.8		105.8				
6 6 94	14 37 25		14.3			795.3		106.0				
6 6 94	15 37 25		14.5			797.5		106.3				
6 6 94	16 37 25		14.3			796.4		106.2				
6 6 94	17 37 25		14.3			796.0		106.1				

FAX. To: BOLIVONG TANOVAN @ (503)326-4161
JIM ATHEARN @ (503)326-7328
HARDCOPY TO: BOB DACH

PROJECT: JDA	DATE: 6/10/94

LOCATION:	1	2	3	1
TIME:	0535	0551	0607	0625
BP(BAR):	761	761	761	761
TBP(PT):	918	846	809	869
TDG(PT/BAR):	120.6	111.2	106.3	114.2
TEMP:	15.2°C	15.1°C	15.1°C	15.1°C
SPILL:	17.2 kcfs	→	→	→
DISCHARGE:	175.7 kcfs	→	→	→

AVERAGE TDG: 113.1

COMMENTS: (Shore line mortality, active predation, weather cond., etc.)
* Adult spill pattern, calm, very little predation.

(X) TDA READINGS WILL NOT BE AVAILABLE UNTIL ≈ 1100 hrs. ≠ BOAT PROBLEMS.

PREDETERMINED LOCATIONS:

JDA-1: Half-way between spillbays 1 & 20, across from the end of the nav lockguide wall at the boat restricted zone boundary (two readings, 30 minutes between readings).

JDa-2: Half-way between spill bays 1 & 20, *underneath power lines (one* reading).

JDA-3: Half-way between powerhouse bays 1 & 20, underneath power lines (one reading).

TDA-1: Hid-river channel across from green Coast Guard channel marker just downstream of nav lock entrance (two readings, 30 minutes between readings).

TDA-2 : Approximately 200 meters from the Oregon shore, across from green Coast Guard channel marker [one reading).

PROBLEMS: Bob Dach (503)296-8968 (home)
Gary Johnson (503)326-6073 (portland dist.)
(509)427-8652 (-hone)

Attachment 15

APPENDIX D DATA SUMMARIES

The following data was obtained from the Fish Passage Center. Data is available for the period from approximately May 11, 1994 through June 30, 1994. The data as provided by Fish Passage Center consisted of a number of daily summary reports covering containing approximately one weeks data. The study team unbound these reports and prepared a separate data set in chronically order for each type of data. The majority of the monitoring activities ceased on June 20, 1994 when the emergency spill stopped. The external examination of smolts conducted by the Smolt Monitoring Program continued until September 16, 1994. No external clinical signs of GBT were detected during the period of July 1, 1994 to September 16, 1994. The daily summaries for this period were omitted from Appendix D.

The following types of data are included in this section:

Draft Conclusions and Recommendations

Cover Sheet and Abbreviations

Lower Columbia River Smolt Monitoring Program Results- External

Snake River Smolt Monitoring Program Results - External

Separator Results - External

Lateral Line and Internal Symptoms - Juvenile Hatchery Steelhead

Fish Guidance Efficiency Monitoring - External

Resident Fish Monitoring - External

Net Pen Monitoring

Adult Monitoring - External

Total Gas Pressure - Daily Averages and Instantaneous Highs

Total Gas Pressure - Average of 12 highest Reading, 24 hour Averages, Highest Reading

Total Gas Pressure - Tailwater Instantaneous From Manually Deployed Probes

FISH PASSAGE CENTER

2501 S.W. FIRST AVE. • SUITE 230 • PORTLAND, OR 97201-4752
PHONE (503) 230-4099 • FAX (503) 230-7559

MEMORANDUM

DATE: June 10, 1994

TO: Interested Parties

FROM: Michele DeHart, FPC

RE: Dally Dissolved Gas and Biological Monitoring Data - PLEASE NOTE:

Attached is the daily monitoring information. The following points should be considered in utiliig this information. Please call if you have any questions regarding this information.

- The dissolved gas data from redundant sites is being collected on a daily basis by the COE. The COE has decided not to provide the data. The situation is being discussed.
- Several modifications of sampling technique have occurred which have been reflected in the incidence of bubbles; specifically, June 2 at Bonneville Dam and June 6 at John Day Dam.
- The external incidence of gas bubbles is documented on the basis of examination of a large number of fish at each site. The sample numbers are adequate to detect signs of GBT and most sites monitor more fish than required.
- The lateral line microscopic monitoring is conducted three times a week . A sample of 30 hatchery steelhead are sacrificed for the examination three times a week.' The lateral line is observed in a two step process,. including an examina tion of the intact lateral line with a dissecting scope (lateral line *external),* and an examination of the lateral line after the skin is peeled back (lateral line internal).
- The lateral line microscopic and internal examinations record all symptoms. There is no indication of severity in this data. Thus far all symptoms are classified as minor, that is few bubbles.
- Tre lateral line bubbles are not indicative of direct mortality or morbidity. In addition, the relation of exhibited lateral line bubbles to nitrogen supersaturation is not clear. The National Marine Fisheries Service has convened a panel to assess this information.
- Samples of steelhead were sacrificed at Lower Granite Dam for microscopic sampling on June 1 and on May 27. Lower Granite Dam is upstream from the spill passage program. The dissolved gas standard of 110 % was exceeded on one hour, on one day from May 18 through May 31. On both May 27 and June 1, 25% of the steelhead sampled showed signs of gas bubble trauma.
- The lateral line microscopic data does not seem to correlate with dissolved gas level or spill level. The lateral line symptoms may relate to the manner in which the fish are collected and sacrificed for examination.

Gas Bubble Symptom Monitoring Summary

Abbreviations:

HCHl = Hatchery Yearling Chinook
WCH1 = Wild Yearling Chinook
CHO = Subyearling Chinook
HST = Hatchery Steelhead
WST = Wild Steelhead
HSO = Hatchery Sockeye
WSO = Wild Sockeye
co = Coho

Samp = Number of each species examined
Obs = Number of fish observed with gas bubble symptoms
% GBS =(# Obs / # Samp) X 100
% TDG = Percent Total Dissolved Gas saturation
Morts = Number of mortalities

NMFS sampling Programs

Juvenile salmonid sampling at FGE projects:

Fish that are guided into the gatewell at projects testing guidance devices are observed for external symptoms. A subsample of these fish are observed for gas bubbles in the lateral line. The occurrence of symptoms is expressed as a percent of me total number of fish observed.

River Reach sampling:

Salmonida are observed as described above. Nonsalmonids consist of resident fish.

Adult sampling:

Adults are observed for external signs of gas bubble trauma at Lower Granite, Ice Harbor and Bonneville dams.

1994 LOWER COLUMBIA SMP GAS BUBBLE SYMPTOMS

		MCN			JDA			BON		
		# OBS	# SAM	% GBS	# OBS	# SAM	% GBS	# OBS	# SAM	% GBS
05/11	CH1	0	1,246	0.0%	0	113	0.0%	0	101	0.0%
	CHO	0	5	0.0%	---	0	---	0	103	0.0%
	HST	0	346	0.0%	0	139	0.0%	0	103	0.0%
	WST	0	68	0.0%	0	103	0.0%	0	100	0.0%
	co	0	958	0.0%	0	118	0.0%	0	102	0.0%
	HSO	0	17	0.0%	0	22	0.0%	0	4	0.0%
	wso	0	286	0.0%	0	132	0.0%	---	56	---
	All Species	**0**	**2,926**	**0.0%**	**0**	**627**	**0.0%**	**0**	**569**	**0.0%**
05/12	CH1	0	1,336	0.0%	0	775	0.0%	0	100	0.0%
	CHO	0	15	0.0%	0	1	0.0%	0	100	0.0%
	HST	0	261	0.0%	0	347	0.0%	0	113	0.0%
	WST	0	57	0.0%	0	185	0.0%	0	107	0.0%
	co	0	886	0.0%	0	341	0.0%	0	100	0.0%
	HSO	0	5	0.0%	0	6	0.0%	---	0	---
	wso	0	182	0.0%	0	147	0.0%	0	100	0.0%
	All Species	**0**	**2,742**	**0.0%**	**0**	**1,802**	**0.0%**	**0**	**620**	**0.0%**
05/13	CH1	0	1,033	0.0%	0	121	0.0%	0	104	0.0%
	CHO	---	0	---	---	0	---	0	104	0.0%
	HST	0	204	0.0%	0	110	0.0%	0	100	0.0%
	WST	0	50	0.0%	0	105	0.0%	1	108	0.9%
	co	0	657	0.0%	0	104	0.0%	0	100	0.0%
	HSO	0	5	0.0%	0	11	0.0%	0	13	0.0%
	wso	0	121	0.0%	0	114	0.0%	0	105	0.0%
	All Species	**0**	**2,070**	**0.0%**	**0**	**565**	**0.0%**	**1**	**634**	**0.2%**
05/14	CH1	0	899	0.0%	0	222	0.0%	0	163	0.0%
	CHO	---	0	---	---	0	---	0	134	0.0%
	HST	0	146	0.0%	0	120	0.0%	0	113	0.0%
	WST	0	48	0.0%	0	97	0.0%	0	106	0.0%
	co	0	396	0.0%	0	146	0.0%	0	353	0.0%
	HSO	---	0	---	0	5	0.0%	0	5	0.0%
	wso	0	94	0.0%	0	105	0.0%	0	147	0.0%
	All Species	**0**	**1,583**	**0.0%**	**0**	**695**	**0.0%**	**0**	**1,021**	**0.0%**
05/15	CH1	0	1,188	0.0%	0	103	0.0%	0	175	0.0%
	CHO	0	16	0.0%	0	1	0.0%	0	122	0.0%
	HST	0	170	0.0%	0	109	0.0%	0	98	0.0%
	WST	0	44	0.0%	0	100	0.0%	1	94	1.1%
	co	0	323	0.0%	0	134	0.0%	0	426	0.0%
	HSO	0	3	0.0%	0	15	0.0%	0	12	0.0%
	wso	0	62	0.0%	0	127	0.0%	0	142	0.0%
	All Species	**0**	**1,806**	**0.0%**	**0**	**589**	**0.0%**	**1**	**1,069**	**0.1%**
05/16	CH1	0	1,068	0.0%	0	104	0.0%	0	107	0.0%
	CHO	0	8	0.0%	---	0	---	0	103	0.0%
	HST	0	93	0.0%	0	122	0.0%	0	101	0.0%
	WST	0	28	0.0%	0	68	0.0%	0	62	0.0%
	co	0	168	0.0%	0	109	0.0%	0	104	0.0%
	HSO	0	2	0.0%	0	9	0.0%	0	4	0.0%
	WSO	0	72	0.0%	0	140	0.0%	0	115	0.0%
	All Species	**0**	**1,439**	**0.0%**	**0**	**552**	**0.0%**	**0**	**596**	**0.0%**
05/17	CH1	0	966	0.0%	0	109	0.0%	0	103	0.0%
	CHO	0	7	0.0%	---	0	---	0	127	0.0%
	HST	0	83	0.0%	0	101	0.0%	1	100	1.0%
	WST	0	19	0.0%	0	91	0.0%	4	101	4.0%
	co	0	170	0.0%	0	131	0.0%	0	101	0.0%
	HSO	0	2	0.0%	0	12	0.0%	0	16	0.0%
	wso	0	58	0.0%	0	68	0.0%	0	116	0.0%
	All Species	**0**	**1,305**	**0.0%**	**0**	**512**	**0.0%**	**5**	**664**	**0.8%**

1994 LOWER COLUMBIA SMP GAS BUBBLE SYMPTOMS

		MCN			JDA			BON		
		# OBS	# SAM	% GBS	# OBS	# SAM	% GBS	# OBS	# SAM	% GBS
05/18	CH1	0	1,856	0.0%	0	115	0.0%	0	111	0.0%
	CHO	0	12	0.0%	0	2	0.0%	0	102	0.0%
	HST	0	78	0.0%	0	124	0.0%	0	103	0.0%
	WST	0	21	0.0%	0	57	0.0%	1	102	1.0%
	CO	0	151	0.0%	0	126	0.0%	0	100	0.0%
	HSO	0	3	0.0%	0	10	0.0%	0	4	0.0%
	wso	0	115	0.0%	0	129	0.0%	0	102	0.0%
	Ail Specie	**0**	**2,236**	**0.0%**	**0**	**563**	**0.0%**	**1**	**624**	**0.2%**
05/19	CH1	0	1,927	0.0%	0	128	0.0%	0	157	0.0%
	CHO	0	11	0.0%	0	1	0.0%	0	103	0.0%
	HST	0	112	0.0%	0	100	0.0%	0	105	0.0%
	WST	0	36	0.0%	0	111	0.0%	5	89	5.6%
	co	0	87	0.0%	0	156	0.0%	0	222	0.0%
	HSO	0	3	0.0%	0	5	0.0%	0	6	0.0%
	wso	0	152	0.0%	0	94	0.0%	0	102	0.0%
	All Specie	**0**	**2,328**	**0.0%**	**0**	**595**	**0.0%**	**5**	**784**	**0.6%**
05/20	CH1	0	1,105	0.0%	0	118	0.0%	0	101	0.0%
	CHO	0	15	0.0%	0	2	0.0%	0	100	0.0%
	HST	0	114	0.0%	0	115	0.0%	1	92	1.1%
	WST	0	28	0.0%	0	92	0.0%	2	61	3.3%
	co	0	69	0.0%	0	106	0.0%	0	100	0.0%
	HSO	0	5	0.0%	0	2	0.0%	0	2	0.0%
	wso	0	133	0.0%	0	81	0.0%	0	100	0.0%
	Ail Speclea	**0**	**1,469**	**0.0%**	**0**	**516**	**0.0%**	**3**	**556**	**0.5%**
05/21	CH1	0	1,376	0.0%	0	129	0.0%	0	113	0.0%
	CHO	0	29	0.0%	0	1	0.0%	0	108	0.0%
	HST	0	117	0.0%	0	125	0.0%	0	34	0.0%
	WST	0	37	0.0%	0	92	0.0%	0	18	0.0%
	co	0	57	0.0%	0	107	0.0%	0	111	0.0%
	nso	0	4	0.0%	---	0	---	0	1	0.0%
	wso	0	201	0.0%	0	116	0.0%	0	24	0.0%
	All Speclea	**0**	**1,821**	**0.0%**	**0**	**570**	**0.0%**	**0**	**409**	**0.0%**
05/22	CH1	0	1,574	0.0%	0	105	0.0%	0	43	0.0%
	CHO	0	26	0.0%	---	0	---	0	205	0.0%
	HST	0	87	0.0%	0	104	0.0%	0	20	0.0%
	WST	0	31	0.0%	0	26	0.0%	0	13	0.0%
	co	0	45	0.0%	0	110	0.0%	0	101	0.0%
	HSO	0	8	0.0%	0	1	0.0%	---	0	---
	wso	0	392	0.0%	0	89	0.0%	0	4	0.0%
	Ail Species	**0**	**2,163**	**0.0%**	**0**	**435**	**0.0%**	**0**	**386**	**0.0%**
05/23	CH1	0	1,579	0.0%	0	104	0.0%	0	38	0.0%
	CHO	0	16	0.0%	0	1	0.0%	0	100	0.0%
	HST	0	118	0.0%	0	126	0.0%	0	12	0.0%
	WST	0	52	0.0%	0	106	0.0%	0	12	0.0%
	co	0	24	0.0%	0	100	0.0%	0	101	0.0%
	HSO	0	15	0.0%	0	107	0.0%	0	2	0.0%
	wso	0	312	0.0%	0	1	0.0%	0	16	0.0%
	Ail Species	**0**	**2,116**	**0.0%**	**0**	**545**	**0.0%**	**0**	**281**	**0.0%**
05/24	CH1	0	1,540	0.0%	0	128	0.0%	0	79	0.0%
	CHO	0	27	0.0%	0	2	0.0%	0	106	0.0%
	HST	0	181	0.0%	0	282	0.0%	0	24	0.0%
	WST	0	46	0.0%	0	143	0.0%	0	19	0.0%
	co	0	29	0.0%	0	143	0.0%	0	101	0.0%
	HSO	0	9	0.0%	0	3	0.0%	0	1	0.0%
	wso	0	589	0.0%	0	109	0.0%	0	16	0.0%
	Ail Species	**0**	**2,421**	**0.0%**	**0**	**810**	**0.0%**	**0**	**346**	**0.0%**

1994 LOWER COLUMBIA SMP GAS BUBBLE SYMPTOMS

		MCN			JDA			BON		
		# OBS	# SAM	% GBS	# OBS	# SAM	% GBS	# OBS	# SAM	% GBS
05/25	CH1	0	1,280	0.0%	0	74	0.0%	0	48	0.0%
	CHO	0	35	0.0%	—	0	—	0	100	0.0%
	HST	0	221	0.0%	0	72	0.0%	0	34	0.0%
	WST	0	40	0.0%	0	47	0.0%	0	31	0.0%
	CO	0	42	0.0%	0	16	0.0%	0	100	0.0%
	HSO	0	4	0.0%	0	0	—	0	2	0.0%
	WSO	0	306	0.0%	0	76	0.0%	0	40	0.0%
	ALL **Species**	**0**	**1,928**	**0.0%**	**0**	**285**	**0.0%**	**0**	**355**	**0.0%**
05/26	CH1	0	1,151	0.0%	0	148	0.0%	0	69	0.0%
	CHO	0	23	0.0%	0	1	0.0%	0	100	0.0%
	HST	1	192	0.5%	0	111	0.0%	0	54	0.0%
	WST	0	37	0.0%	0	104	0.0%	0	45	0.0%
	CO	0	34	0.0%	0	131	0.0%	0	127	0.0%
	HSO	0	12	0.0%	0	2	0.0%	0	1	0.0%
	WSO	0	243	0.0%	0	122	0.0%	1	37	2.7%
	ALL SPECIES	**1**	**1,692**	**0.1%**	**0**	**619**	**0.0%**	**1**	**433**	**0.2%**
05/27	CH1	0	454	0.0%	0	115	0.0%	0	107	0.0%
	CHO	0	5	0.0%	0	8	0.0%	0	113	0.0%
	HST	0	48	0.0%	0	137	0.0%	0	104	0.0%
	WST	0	7	0.0%	0	98	0.0%	2	105	1.9%
	CO	0	8	0.0%	0	100	0.0%	0	102	0.0%
	HSO	0	6	0.0%	0	6	0.0%	0	2	0.0%
	WSO	0	83	0.0%	0	128	0.0%	0	106	0.0%
	All SPECIES	**0**	**611**	**0.0%**	**0**	**592**	**0.0%**	**2**	**639**	**0.3%**
05/28	CH1	0	1,341	0.0%	0	120	0.0%	0	109	0.0%
	CHO	0	9	0.0%	0	2	0.0%	0	126	0.0%
	HST	3	138	2.2%	0	127	0.0%	0	102	0.0%
	WST	0	27	0.0%	0	80	0.0%	1	109	0.9%
	CO	0	23	0.0%	0	86	0.0%	0	110	0.0%
	HSO	0	11	0.0%	0	3	0.0%	0	2	0.0%
	WSO	0	402	0.0%	0	132	0.0%	0	89	0.0%
	ALL SPECIES	**3**	**1,951**	**0.2%**	**0**	**550**	**0.0%**	**1**	**647**	**0.2%**
05/29	CH1	0	1,178	0.0%	0	113	0.0%	0	109	0.0%
	CHO	0	8	0.0%	0	2	0.0%	0	112	0.0%
	HST	0	110	0.0%	0	104	0.0%	0	60	0.0%
	WST	0	25	0.0%	0	28	0.0%	0	52	0.0%
	CO	0	7	0.0%	0	94	0.0%	0	104	0.0%
	HSO	0	10	0.0%	0	6	0.0%	0	4	0.0%
	WSO	0	218	0.0%	0	129	0.0%	0	95	0.0%
	ALL SPECIES	**0**	**1,556**	**0.0%**	**0**	**476**	**0.0%**	**0**	**536**	**0.0%**
05130	CH1	0	945	0.0%	0	103	0.0%	0	102	0.0%
	CHO	0	9	0.0%	0	1	0.0%	0	100	0.0%
	HST	1	74	1.4%	0	96	0.0%	0	68	0.0%
	WST	0	13	0.0%	0	34	0.0%	0	53	0.0%
	CO	0	7	0.0%	0	36	0.0%	0	101	0.0%
	HSO	0	4	0.0%	0	3	0.0%	0	3	0.0%
	WSO	0	161	0.0%	0	128	0.0%	0	101	0.0%
	ALL **Species**	**1**	**1,213**	**0.1%**	**0**	**401**	**0.0%**	**0**	**528**	**0.0%**
05/31	CH1	0	568	0.0%	0	125	0.0%	0	83	0.0%
	CHO	0	8	0.0%	—	0	—	0	121	0.0%
	HST	0	172	0.0%	0	156	0.0%	0	83	0.0%
	WST	0	39	0.0%	0	127	0.0%	0	40	0.0%
	CO	0	7	0.0%	0	86	0.0%	0	105	0.0%
	HSO	0	2	0.0%	0	2	0.0%	0	3	0.0%
	WSO	0	130	0.0%	0	110	0.0%	0	103	0.0%
	ALL SPECIES	**0**	**926**	**0.0%**	**0**	**606**	**0.0%**	**0**	**538**	**0.0%**

1994 Lower Columbia River Smolt Monitoring Program Gas Bubble Symptoms

		McNary Dam			John Day Dam			Bonneville Dam		
Date	Species	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS
06/01	CH1	0	968	0.0%	0	150	0.0%	0	76	0.0%
	CHO	0	8	0.0%	0	2	0.0%	0	100	0.0%
	HST	0	256	0.0%	0	197	0.0%	0	53	0.0%
	WST	0	35	0.0%	0	38	0.0%	0	31	0.0%
	CO	0	7	0.0%	0	236	0.0%	0	101	0.0%
	HSO	0	11	0.0%	0	1	0.0%	0	2	0.0%
	WSO	0	141	0.0%	0	89	0.0%	0	48	0.0%
	All Species	**0**	**1,426**	**0.0%**	**0**	**713**	**0.0%**	**0**	**411**	**0.0%**
06/02	CH1	0	719	0.0%	0	107	0.0%	0	99	0.0%
	CHO	0	24	0.0%	0	5	0.0%	0	152	0.0%
	HST	0	213	0.0%	0	67	0.0%	0	52	0.0%
	WST	0	11	0.0%	0	9	0.0%	0	42	0.0%
	CO	0	6	0.0%	0	37	0.0%	0	107	0.0%
	HSO	0	4	0.0%	0	2	0.0%	0	3	0.0%
	WSO	0	172	0.0%	0	111	0.0%	0	85	0.0%
	All Species	**0**	**1,149**	**0.0%**	**0**	**338**	**0.0%**	**0**	**540**	**0.0%**
06/03	CH1	0	880	0.0%	0	117	0.0%	0	70	0.0%
	CHO	0	27	0.0%	0	2	0.0%	0	110	0.0%
	HST	0	373	0.0%	0	102	0.0%	0	61	0.0%
	WST	0	37	0.0%	0	60	0.0%	0	34	0.0%
	CO	0	2	0.0%	0	122	0.0%	0	100	0.0%
	HSO	0	4	0.0%	0	2	0.0%	0	2	0.0%
	WSO	0	193	0.0%	0	105	0.0%	0	45	0.0%
	All Species	**0**	**1,516**	**0.0%**	**0**	**510**	**0.0%**	**0**	**422**	**0.0%**
06/04	CH1	0	713	0.0%	0	129	0.0%	0	110	0.0%
	CHO	0	30	0.0%	0	4	0.0%	0	102	0.0%
	HST	0	289	0.0%	0	59	0.0%	0	44	0.0%
	WST	0	28	0.0%	0	8	0.0%	0	26	0.0%
	CO	0	3	0.0%	0	45	0.0%	0	121	0.0%
	HSO	0	2	0.0%	0	1	0.0%	—	0	—
	WSO	0	102	0.0%	0	61	0.0%	0	40	0.0%
	All Species	**0**	**1,167**	**0.0%**	**0**	**307**	**0.0%**	**0**	**443**	**0.0%**
06/05	CH1	0	476	0.0%	0	127	0.0%	0	83	0.0%
	CHO	0	31	0.0%	0	12	0.0%	0	104	0.0%
	HST	0	155	0.0%	0	82	0.0%	0	57	0.0%
	WST	0	14	0.0%	0	12	0.0%	0	19	0.0%
	CO	0	4	0.0%	0	49	0.0%	0	111	0.0%
	HSO	0	7	0.0%	0	1	0.0%	—	0	—
	WSO	0	132	0.0%	0	102	0.0%	0	41	0.0%
	All Species	**0**	**819**	**0.0%**	**0**	**385**	**0.0%**	**0**	**415**	**0.0%**
06/06	CH1	0	272	0.0%	0	140	0.0%	0	112	0.0%
	CHO	0	25	0.0%	0	8	0.0%	0	105	0.0%
	HST	0	112	0.0%	0	56	0.0%	0	75	0.0%
	WST	0	14	0.0%	0	14	0.0%	0	34	0.0%
	CO	0	3	0.0%	0	24	0.0%	0	136	0.0%
	HSO	—	0	—	—	0	—	—	0	—
	WSO	0	71	0.0%	0	23	0.0%	0	45	0.0%
	All Species	**0**	**497**	**0.0%**	**0**	**265**	**0.0%**	**0**	**507**	**0.0%**
06/07	CH1	0	362	0.0%	0	116	0.0%	0	112	0.0%
	CHO	0	24	0.0%	0	22	0.0%	0	122	0.0%
	HST	0	204	0.0%	0	51	0.0%	0	48	0.0%
	WST	0	18	0.0%	0	6	0.0%	0	22	0.0%
	CO	0	4	0.0%	0	16	0.0%	0	106	0.0%
	HSO	0	10	0.0%	—	0	—	—	0	—
	WSO	0	78	0.0%	0	30	0.0%	0	37	0.0%
	All Species	**0**	**700**	**0.0%**	**0**	**241**	**0.0%**	**0**	**447**	**0.0%**

1994 Lower Columbia River Smolt Monitoring Program Gas Bubble Symptoms

		McNary Dam			John Day Dam			Bonneville Dam		
Date	Species	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS
06/07	CH1	0	362	0.0%	0	116	0.0%	0	112	0.0%
	CHO	0	24	0.0%	0	22	0.0%	0	122	0.0%
	HST	0	204	0.0%	0	51	0.0%	0	48	0.0%
	WST	0	18	0.0%	0	6	0.0%	0	22	0.0%
	CO	0	4	0.0%	0	16	0.0%	0	106	0.0%
	HSO	0	10	0.0%	---	0	---	---	0	---
	WSO	0	78	0.0%	0	30	0.0%	0	37	0.0%
	All Species	**0**	**700**	**0.0%**	**0**	**241**	**0.0%**	**0**	**447**	**0.0%**
06/08	CH1			---	0	156	0.0%	0	100	0.0%
	CHO			---	0	12	0.0%	0	100	0.0%
	HST			---	0	40	0.0%	0	47	0.0%
	WST			---	0	6	0.0%	0	19	0.0%
	CO			---	0	11	0.0%	0	110	0.0%
	HSO			---	---	0	---	0	1	0.0%
	WSO			---	0	62	0.0%	0	25	0.0%
	All Species	**0**	**0**	**---**	**0**	**287**	**0.0%**	**0**	**402**	**0.0%**
06/09	CH1	0	99	0.0%	0	107	0.0%	0	94	0.0%
	CHO	0	8	0.0%	0	11	0.0%	0	121	0.0%
	HST	0	253	0.0%	0	33	0.0%	0	44	0.0%
	WST	0	24	0.0%	0	11	0.0%	0	21	0.0%
	CO	0	2	0.0%	0	14	0.0%	0	100	0.0%
	HSO	0	3	0.0%	0	1	0.0%	0	1	0.0%
	WSO	0	27	0.0%	0	95	0.0%	0	22	0.0%
	All Species	**0**	**416**	**0.0%**	**0**	**272**	**0.0%**	**0**	**403**	**0.0%**
06/10	CH1	0	472	0.0%	0	100	0.0%	0	108	0.0%
	CHO	0	15	0.0%	0	6	0.0%	0	103	0.0%
	HST	0	298	0.0%	0	25	0.0%	0	48	0.0%
	WST	0	27	0.0%	0	4	0.0%	0	30	0.0%
	CO	0	4	0.0%	0	6	0.0%	0	101	0.0%
	HSO	0	8	0.0%	0	2	0.0%	0	3	0.0%
	WSO	0	57	0.0%	0	51	0.0%	0	21	0.0%
	All Species	**0**	**881**	**0.0%**	**0**	**194**	**0.0%**	**0**	**414**	**0.0%**
06/11	CH1	0	397	0.0%	0	166	0.0%	0	103	0.0%
	CHO	0	19	0.0%	0	8	0.0%	0	123	0.0%
	HST	0	130	0.0%	0	15	0.0%	0	19	0.0%
	WST	0	2	0.0%	0	9	0.0%	0	14	0.0%
	CO	0	3	0.0%	0	8	0.0%	0	105	0.0%
	HSO	0	7	0.0%	0	1	0.0%	0	1	0.0%
	WSO	0	45	0.0%	0	44	0.0%	0	23	0.0%
	All Species	**0**	**603**	**0.0%**	**0**	**251**	**0.0%**	**0**	**388**	**0.0%**
06/12	CH1	0	807	0.0%	0	206	0.0%	0	108	0.0%
	CHO	0	106	0.0%	0	10	0.0%	0	108	0.0%
	HST	0	81	0.0%	0	19	0.0%	0	14	0.0%
	WST	0	10	0.0%	0	8	0.0%	0	11	0.0%
	CO	0	3	0.0%	0	4	0.0%	0	102	0.0%
	HSO	0	8	0.0%	---	0	---	---	0	---
	WSO	0	53	0.0%	0	20	0.0%	0	28	0.0%
	All Species	**0**	**1,068**	**0.0%**	**0**	**267**	**0.0%**	**0**	**371**	**0.0%**
06/13	CH1	0	654	0.0%	0	142	0.0%	0	101	0.0%
	CHO	0	145	0.0%	0	9	0.0%	0	100	0.0%
	HST	0	114	0.0%	0	53	0.0%	0	17	0.0%
	WST	0	7	0.0%	0	5	0.0%	0	11	0.0%
	CO	0	7	0.0%	0	6	0.0%	0	106	0.0%
	HSO	0	5	0.0%	---	0	---	---	0	---
	WSO	0	30	0.0%	0	20	0.0%	0	19	0.0%
	All Species	**0**	**962**	**0.0%**	**0**	**235**	**0.0%**	**0**	**354**	**0.0%**

1994 Lower Columbii River Smolt Monitoring Program Gas Bubble Symptoms

		McNary Dam			John Day Dam			Bonneville Dam		
Date	Species	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS
06/14	CH1	0	999	0.0%	0	141	0.0%	0	71	0.0%
	CHO	0	417	0.0%	0	13	0.0%	0	114	0.0%
	HST	0	91	0.0%	0	34	0.0%	0	18	0.0%
	WST	0	8	0.0%	0	3	0.0%	0	14	0.0%
	CO	—	0	—	0	8	0.0%	0	101	0.0%
	HSO	0	7	0.0%	0	2	0.0%	—	0	—
	WSO	0	47	0.0%	0	28	0.0%	0	6	0.0%
	All Species	**0**	**1,569**	**0.0%**	**0**	**229**	**0.0%**	**0**	**324**	**0.0%**
06/15	CH1	0	515	0.0%	0	147	0.0%	0	110	0.0%
	CHO	0	409	0.0%	0	23	0.0%	0	100	0.0%
	HST	0	198	0.0%	0	29	0.0%	0	22	0.0%
	WST	0	12	0.0%	0	2	0.0%	0	8	0.0%
	CO	0	4	0.0%	0	13	0.0%	0	98	0.0%
	HSO	0	2	0.0%	—	0	—	—	0	—
	WSO	0	30	0.0%	0	38	0.0%	0	15	0.0%
	All Species	**0**	**1,170**	**0.0%**	**0**	**252**	**0.0%**	**0**	**353**	**0.0%**
06/16	CH1	0	708	0.0%	0	106	0.0%	0	105	0.0%
	CHO	0	447	0.0%	0	54	0.0%	0	120	0.0%
	HST	0	100	0.0%	0	24	0.0%	0	25	0.0%
	WST	0	4	0.0%	0	2	0.0%	0	6	0.0%
	CO	0	2	0.0%	0	12	0.0%	0	101	0.0%
	HSO	0	4	0.0%	—	0	—	0	1	0.0%
	WSO	0	31	0.0%	0	19	0.0%	0	10	0.0%
	All Species	**0**	**1,296**	**0.0%**	**0**	**217**	**0.0%**	**0**	**368**	**0.0%**
06/17	CH1	0	316	0.0%	0	102	0.0%	0	117	0.0%
	CHO	0	365	0.0%	0	41	0.0%	0	105	0.0%
	HST	0	63	0.0%	0	13	0.0%	0	15	0.0%
	WST	0	8	0.0%	0	4	0.0%	0	7	0.0%
	CO	0	4	0.0%	0	2	0.0%	0	100	0.0%
	HSO	0	2	0.0%	—	0	—	—	0	—
	WSO	0	10	0.0%	0	17	0.0%	0	7	0.0%
	All Species	**0**	**768**	**0.0%**	**0**	**179**	**0.0%**	**0**	**351**	**0.0%**
06/18	CH1	0	227	0.0%	0	101	0.0%	0	105	0.0%
	CHO	0	968	0.0%	0	102	0.0%	0	146	0.0%
	HST	0	224	0.0%	0	4	0.0%	0	12	0.0%
	WST	0	15	0.0%	0	1	0.0%	0	3	0.0%
	CO	0	3	0.0%	0	4	0.0%	0	105	0.0%
	HSO	0	2	0.0%	—	0	—	0	3	0.0%
	WSO	0	12	0.0%	0	13	0.0%	0	7	0.0%
	All Species	**0**	**1,451**	**0.0%**	**0**	**225**	**0.0%**	**0**	**381**	**0.0%**
06/19	CH1	0	242	0.0%	0	113	0.0%	0	119	0.0%
	CHO	0	1,805	0.0%	0	117	0.0%	0	102	0.0%
	HST	0	162	0.0%	0	5	0.0%	0	13	0.0%
	WST	0	9	0.0%	0	5	0.0%	0	7	0.0%
	CO	0	2	0.0%	—	0	—	0	72	0.0%
	HSO	0	5	0.0%	—	0	—	—	0	—
	WSO	0	15	0.0%	0	12	0.0%	0	6	0.0%
	All Species	**0**	**2,240**	**0.0%**	**0**	**252**	**0.0%**	**0**	**319**	**0.0%**
06/20	CH1			—	0	120	0.0%	0	108	0.0%
	CHO			—	0	106	0.0%	0	107	0.0%
	HST			—	0	7	0.0%	0	7	0.0%
	WST			—	0	3	0.0%	—	0	—
	CO			—	0	6	0.0%	0	52	0.0%
	HSO			—	0	1	0.0%	—	0	—
	WSO			—	0	26	0.0%	0	4	0.0%
	All Species	**0**	**0**	**ERR**	**0**	**269**	**0.0%**	**0**	**278**	**0.0%**

1994 Lower Columbia River Smolt Monitoring Program Gas Bubble Symptoms

		McNary Dam			John Day Dam			Bonneville Dam		
Date	Species	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS
06/18	CH1	0	227	0.0%	0	101	0.0%	0	105	0.0%
	CHO	0	968	0.0%	0	102	0.0%	0	146	0.0%
	HST	0	224	0.0%	0	4	0.0%	0	12	0.0%
	WST	0	15	0.0%	0	1	0.0%	0	3	0.0%
	CO	0	3	0.0%	0	4	0.0%	0	105	0.0%
	HSO	0	2	0.0%	—	0	—	0	3	0.0%
	WSO	0	12	0.0%	0	13	0.0%	0	7	0.0%
	All Species	**0**	**1,451**	**0.0%**	**0**	**225**	**0.0%**	**0**	**381**	**0.0%**
06/19	CH1	0	242	0.0%	0	113	0.0%	0	119	0.0%
	CHO	0	1,805	0.0%	0	117	0.0%	0	102	0.0%
	HST	0	162	0.0%	0	5	0.0%	0	13	0.0%
	WST	0	9	0.0%	0	5	0.0%	0	7	0.0%
	CO	0	2	0.0%	—	0	—	0	72	0.0%
	HSO	0	5	0.0%	—	0	—	—	0	—
	WSO	0	15	0.0%	0	12	0.0%	0	6	0.0%
	All Species	**0**	**2,240**	**0.0%**	**0**	**252**	**0.0%**	**0**	**319**	**0.0%**
06/20	CH1	0	159	0.0%	0	120	0.0%	0	108	0.0%
	CHO	0	1,496	0.0%	0	106	0.0%	0	107	0.0%
	HST	0	522	0.0%	0	7	0.0%	0	7	0.0%
	WST	0	14	0.0%	0	3	0.0%	—	0	—
	CO	0	6	0.0%	0	6	0.0%	0	52	0.0%
	HSO	0	5	0.0%	0	1	0.0%	—	0	—
	WSO	0	11	0.0%	0	26	0.0%	0	4	0.0%
	All Species	**0**	**2,213**	**0.0%**	**0**	**269**	**0.0%**	**0**	**278**	**0.0%**
06/21	CH1	0	277	0.0%	0	105	0.0%	0	120	0.0%
	CHO	0	4,923	0.0%	0	121	0.0%	0	147	0.0%
	HST	0	332	0.0%	0	2	0.0%	0	8	0.0%
	WST	0	17	0.0%	—	0	—	0	4	0.0%
	CO	0	5	0.0%	0	1	0.0%	0	64	0.0%
	HSO	0	6	0.0%	0	1	0.0%	—	0	—
	WSO	0	36	0.0%	0	8	0.0%	0	5	0.0%
	All Species	**0**	**5,596**	**0.0%**	**0**	**238**	**0.0%**	**0**	**348**	**0.0%**
06/22	CH1	0	321	0.0%	0	101	0.0%	0	100	0.0%
	CHO	0	8,613	0.0%	0	112	0.0%	0	103	0.0%
	HST	0	391	0.0%	0	4	0.0%	0	8	0.0%
	WST	0	12	0.0%	0	1	0.0%	0	2	0.0%
	CO	0	4	0.0%	0	4	0.0%	0	52	0.0%
	HSO	0	9	0.0%	0	1	0.0%	0	1	0.0%
	WSO	0	53	0.0%	0	2	0.0%	0	11	0.0%
	All Species	**0**	**9,403**	**0.0%**	**0**	**225**	**0.0%**	**0**	**277**	**0.0%**
06/23	CH1	0	205	0.0%	0	118	0.0%	0	108	0.0%
	CHO	0	8,336	0.0%	0	122	0.0%	0	127	0.0%
	HST	0	191	0.0%	0	4	0.0%	0	4	0.0%
	WST	0	10	0.0%	—	0	—	0	1	0.0%
	CO	0	4	0.0%	0	4	0.0%	0	47	0.0%
	HSO	0	5	0.0%	0	1	0.0%	0	2	0.0%
	WSO	0	33	0.0%	0	4	0.0%	0	3	0.0%
	All Species	**0**	**8,784**	**0.0%**	**0**	**253**	**0.0%**	**0**	**292**	**0.0%**
06/24	CH1			—	0	107	0.0%	0	110	0.0%
	CHO			—	0	104	0.0%	0	101	0.0%
	HST			—	0	2	0.0%	0	6	0.0%
	WST			—	—	0	—	0	3	0.0%
	CO			—	—	0	—	0	32	0.0%
	HSO			—	—	0	—	—	0	—
	WSO			—	0	5	0.0%	0	5	0.0%
	All Species	**0**	**0**	**—**	**0**	**218**	**0.0%**	**0**	**257**	**0.0%**

1994 Lower Columbia Smolt Monitoring Program Gas Bubble Symptoms

		McNary Dam			John Day Dam			Bonneville Dam		
Date	Species	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS
06/25	CH1	0	155	0.0%			—			—
	CHO	0	17,619	0.0%			—			—
	HST	0	134	0.0%			—			—
	WST	0	5	0.0%			—			—
	CO	0	2	0.0%			—			—
	HSO	0	2	0.0%			—			—
	WSO	0	28	0.0%			—			—
	All Species	**0**	**17,945**	**0.0%**	**0**	**0**	**—**	**0**	**0**	**—**
06/26	CH1			—			—			—
	CHO			—			—			—
	HST			—			—			—
	WST			—			—			—
	CO			—			—			—
	HSO			—			—			—
	WSO			—			—			—
	All Species	**0**	**0**	**—**	**0**	**0**	**—**	**0**	**0**	**—**
06/27	CH1	0	87	0.0%	0	109	0.0%	0	104	0.0%
	CHO	0	~~19,635~~ 9,635	0.0%	0	100	0.0%	0	108	0.0%
	HST	0	37	0.0%	0	4	0.0%	0	8	0.0%
	WST	0	1	0.0%	—	0	—	0	1	0.0%
	CO	—	0	—	—	0	—	0	24	0.0%
	HSO	—	0	—	—	0	—	—	0	—
	WSO	0	3	0.0%	0	9	0.0%	—	0	—
	All Species	**0**	**19,763**	**—**	**0**	**222**	**0.0%**	**0**	**245**	**0.0%**
06/28	CH1			—			—			—
	CHO			—			—			—
	HST			—			—			—
	WST			—			—			—
	CO			—			—			—
	HSO			—			—			—
	WSO			—			—			—
	All Species	**0**	**0**	**—**	**0**	**0**	**—**	**0**	**0**	**—**
06/29	CH1	0	105	0.0%	0	122	0.0%	0	106	0.0%
	CHO	0	4,979	0.0%	0	103	0.0%	0	102	0.0%
	HST	0	48	0.0%	—	0	—	—	0	—
	WST	0	5	0.0%	0	1	0.0%	—	0	—
	CO	—	0	—	—	0	—	0	14	0.0%
	HSO	0	1	0.0%	—	0	—	—	0	—
	WSO	0	8	0.0%	0	5	0.0%	0	3	0.0%
	All Species	**0**	**5,146**	**—**	**0**	**231**	**0.0%**	**0**	**225**	**—**
06/30	CH1			—			—			—
	CHO			—			—			—
	HST			—			—			—
	WST			—			—			—
	CO			—			—			—
	HSO			—			—			—
	WSO			—			—			—
	All Species	**0**	**0**	**—**	**0**	**0**	**ERR**	**0**	**0**	**—**
07/01	CH1			—	0	93	0.0%	0	101	0.0%
	CHO			—	0	121	0.0%	0	102	0.0%
	HST			—	0	5	0.0%	0	4	0.0%
	WST			—	0	1	0.0%	0	1	0.0%
	CO			—	0	3	0.0%	0	6	0.0%
	HSO			—	—	0	—	—	0	—
	WSO			—	0	5	0.0%	—	0	—
	All Species	**0**	**0**	**—**	**0**	**228**	**0.0%**	**0**	**214**	**0.0%**

9,635
comment dated
July 8, 1994

1994 SNAKE RIVER SMP GAS BUBBLE SYMPTOMS

		LGR			LGS			LMN		
		# OBS	# SAM	% GBS	# OBS	# SAM	% GBS	# OBS	# SAM	% GBS
05/11	HCH1	0	95	0.0%	0	100	0.0%	0	94	0.0%
	WCH1	0	5	0.0%	0	17	0.0%	0	38	0.0%
	CHO	---	0	---	---	0	---	0	1	0.0%
	HST	0	100	0.0%	0	100	0.0%	0	100	0.0%
	WST	0	100	0.0%	0	14	0.0%	0	11	0.0%
	wso	0	9	0.0%	0	6	0.0%	0	1	0.0%
	All Species	0	309	0.0%	0	237	0.0%	0	245	0.0%
05/12	HCHl	0	96	0.0%	0	113	0.0%	0	100	0.0%
	WCH1	0	3	0.0%	0	34	0.0%	0	60	0.0%
	CHO	---	0	---	---	0	---	---	0	---
	HST	0	100	0.0%	0	101	0.0%	0	100	0.0%
	WST	0	76	0.0%	0	16	0.0%	0	50	0.0%
	wso	0	21	0.0%	0	3	0.0%	0	13	0.0%
	All Species	0	296	0.0%	0	267	0.0%	0	323	0.0%
05/13	HCHl	0	76	0.0%	0	100	0.0%	0	60	0.0%
	WCH1	---	0	---	0	69	0.0%	0	53	0.0%
	CHO	---	0	---	---	0	---	0	3	0.0%
	HST	0	100	0.0%	0	100	0.0%	0	77	0.0%
	WST	0	80	0.0%	0	100	0.0%	0	51	0.0%
	wso	0	19	0.0%	0	27	0.0%	0	14	0.0%
	All Species	0	275	0.0%	0	396	0.0%	0	258	0.0%
05/14	HCHl	0	28	0.0%	0	100	0.0%	4	5,822	0.1%
	WCH1	0	1	0.0%	0	18	0.0%	0	590	0.0%
	CHO	---	0	---	---	0	---	0	6	0.0%
	HST	0	80	0.0%	0	100	0.0%	0	1,832	0.0%
	WST	0	58	0.0%	0	12	0.0%	0	361	0.0%
	wso	0	13	0.0%	0	2	0.0%	0	30	0.0%
	All Species	0	180	0.0%	0	232	0.0%	4	8,641	0.0%
05/15	HCHl	0	99	0.0%	0	100	0.0%	39	3,664	1.1%
	WCH1	0	1	0.0%	0	47	0.0%	0	261	0.0%
	CHO	---	0	---	---	0	---	0	6	0.0%
	HST	0	100	0.0%	0	100	0.0%	2	1,247	0.2%
	WST	0	81	0.0%	0	100	0.0%	1	358	0.3%
	wso	0	13	0.0%	0	9	0.0%	1	14	7.1%
	All Species	0	294	0.0%	0	356	0.0%	43	5,550	0.8%
05/16	HCHl	0	97	0.0%	0	100	0.0%	5	5,772	0.1%
	WCH1	---	0	---	0	21	0.0%	0	434	0.0%
	CHO	---	0	---	---	0	---	0	8	0.0%
	HST	0	100	0.0%	0	100	0.0%	1	2,890	0.0%
	WST	0	43	0.0%	0	34	0.0%	0	426	0.0%
	wso	0	16	0.0%	0	8	0.0%	0	14	0.0%
	All Species	0	256	0.0%	0	263	0.0%	6	9,544	0.1%
05/17	HCHl	0	100	0.0%	0	140	0.0%	0	175	0.0%
	WCH1	---	0	---	0	105	0.0%	0	15	0.0%
	CHO	---	0	---	0	2	0.0%	0	1	0.0%
	HST	0	100	0.0%	0	148	0.0%	0	153	0.0%
	WST	0	24	0.0%	0	102	0.0%	0	17	0.0%
	wso	0	15	0.0%	0	21	0.0%	0	1	0.0%
	All Species	0	239	0.0%	0	518	0.0%	0	362	0.0%

1994 SNAKE RIVER SMP GAS BUBBLE SYMPTOMS

	LGR			LGS			LMN		
	# OBS	# SAM	% GBS	# OBS	# SAM	% GBS	# OBS	# SAM	% GBS
05/18 HCHl	0	99	0.0%	0	100	0.0%	0	4,552	0.0%
WCH1	0	1	0.0%	0	16	0.0%	0	293	0.0%
CHO	---	0	---	---	0	---	0	15	0.0%
HST	0	100	0.0%	0	99	0.0%	0	4,491	0.0%
W S T	0	52	0.0%	0	23	0.0%	0	218	0.0%
wso	0	15	0.0%	0	13	0.0%	0	13	0.0%
All Species	**0**	**267**	**0.0%**	**0**	**251**	**0.0%**	**0**	**9,582**	**0.0%**
05/19 HCH1	0	98	0.0%	0	98	0.0%	0	235	0.0%
WCH1	0	2	0.0%	0	25	0.0%	0	24	0.0%
CHO	---	0	---	0	1	0.0%	0	2	0.0%
HST	0	100	0.0%	0	100	0.0%	0	235	0.0%
WST	0	75	0.0%	0	16	0.0%	0	29	0.0%
wso	0	33	0.0%	0	8	0.0%	---	0	---
All Species	**0**	**308**	**0.0%**	**0**	**248**	**0.0%**	**0**	**525**	**0.0%**
05/20 HCH1	0	98	0.0%	0	79	0.0%	0	100	0.0%
WCH1	0	2	0.0%	0	19	0.0%	0	66	0.0%
CHO	---	0	---	---	0	---	0	10	0.0%
HST	0	100	0.0%	0	96	0.0%	0	100	0.0%
WST	0	75	0.0%	0	29	0.0%	0	56	0.0%
wso	0	33	0.0%	0	9	0.0%	0	20	0.0%
All Species	**0**	**308**	**0.0%**	**0**	**232**	**0.0%**	**0**	**352**	**0.0%**
05/21 HCHl	0	61	0.0%	0	120	0.0%	---	0	---
WCH1	0	8	0.0%	0	17	0.0%	0	9	0.0%
CHO	---	0	---	---	0	---	0	1	0.0%
HST	0	100	0.0%	0	100	0.0%	0	74	0.0%
WST	0	61	0.0%	0	23	0.0%	0	7	0.0%
wso	0	28	0.0%	0	2	0.0%	---	0	---
All Species	**0**	**258**	**0.0%**	**0**	**262**	**0.0%**	**0**	**91**	**0.0%**
05/22 HCHl	0	61	0.0%	0	77	0.0%	0	65	0.0%
WCH1	0	44	0.0%	0	8	0.0%	0	55	0.0%
CHO	---	0	---	0	3	0.0%	0	2	0.0%
HST	0	100	0.0%	0	100	0.0%	0	72	0.0%
WST	0	46	0.0%	0	13	0.0%	0	54	0.0%
wso	0	25	0.0%	0	1	0.0%	0	11	0.0%
All **Species**	**0**	**276**	**0.0%**	**0**	**202**	**0.0%**	**0**	**259**	**0.0%**
05/23 HCHl	0	2	0.0%	0	100	0.0%	0	36	0.0%
WCH1	0	28	0.0%	0	58	0.0%	0	6	0.0%
CHO	0	1	0.0%	0	3	0.0%	---	0	---
HST	0	100	0.0%	0	100	0.0%	1	82	1.2%
WST	0	54	0.0%	0	100	0.0%	0	7	0.0%
wso	0	33	0.0%	0	48	0.0%	---	0	---
All **Species**	**0**	**218**	**0.0%**	**0**	**409**	**0.0%**	**1**	**131**	**0.8%**
05/24 HCHl	0	70	0.0%	0	79	0.0%	0	47	0.0%
WCH1	0	30	0.0%	0	13	0.0%	0	7	0.0%
CHO	---	0	---	0	1	0.0%	---	0	---
HST	0	100	0.0%	0	100	0.0%	0	165	0.0%
WST	0	75	0.0%	0	7	0.0%	0	19	0.0%
wso	0	50	0.0%	0	7	0.0%	0	5	0.0%
All Species	**0**	**325**	**0.0%**	**0**	**207**	**0.0%**	**0**	**243**	**0.0%**

1994 Snake River Smolt Monitoring Program Gas Bubble Symptom

	Species	Lower Granite Dam # Obs	# Samp	% GBS	Little Goose Dam # Obs	# Samp	% GBS	Lower Monumental Dam # Obs	# Samp	% GBS
05/24	HCHl	0	70	0.0%	0	79	0.0%	0	47	0.0%
	WCHl	0	30	0.0%	0	13	0.0%	0	7	0.0%
	CHO	0	0	—	0	1	0.0%	0	0	—
	HST	0	100	0.0%	0	100	0.0%	0	165	0.0%
	WST	0	75	0.0%	0	7	0.0%	0	19	0.0%
	WSO	0	50	0.0%	0	7	0.0%	0	5	0.0%
	All Species	**0**	**325**	**0.0%**	**0**	**207**	**0.0%**	**0**	**243**	**0.0%**
5/25	HCH1	0	63	0.0%	0	34	0.0%	0	254	0.0%
	WCH1	0	21	0.0%	0	10	0.0%	0	23	0.0%
	CHO	0	0	—	0	1	0.0%	0	0	—
	HST	0	100	0.0%	0	100	0.0%	0	675	0.0%
	WST	0	100	0.0%	0	15	0.0%	0	56	0.0%
	WSO	0	35	0.0%	0	2	0.0%	0	7	0.0%
	All Species	**0**	**319**	**0.0%**	**0**	**162**	**0.0%**	**0**	**1,015**	**0.0%**
5/26	HCH1	0	17	0.0%	0	23	0.0%	0	301	0.0%
	WCH1	0	9	0.0%	0	4	0.0%	0	19	0.0%
	CHO	0	0	—	0	0	—	0	1	0.0%
	HST	0	88	0.0%	0	100	0.0%	0	812	0.0%
	WST	0	87	0.0%	0	14	0.0%	0	61	0.0%
	WSO	0	13	0.0%	0	5	0.0%	0	9	0.0%
	All Species	**0**	**214**	**0.0%**	**0**	**146**	**0.0%**	**0**	**1,203**	**0.0%**
5/27	HCH1	0	24	0.0%	0	98	0.0%	0	164	0.0%
	WCH1	0	4	0.0%	0	18	0.0%	0	18	0.0%
	CHO	0	0	—	0	0	—	0	0	—
	HST	0	31	0.0%	0	102	0.0%	0	129	0.0%
	WST	0	31	0.0%	0	9	0.0%	0	14	0.0%
	WSO	0	4	0.0%	0	2	0.0%	0	3	0.0%
	All Species	**0**	**94**	**0.0%**	**0**	**229**	**0.0%**	**0**	**328**	**0.0%**
5/28	HCH1	0	23	0.0%	0	200	0.0%	0	144	0.0%
	WCH1	0	6	0.0%	0	45	0.0%	0	20	0.0%
	CHO	0	0	—	0	0	—	0	0	—
	HST	0	50	0.0%	0	187	0.0%	0	159	0.0%
	WST	0	44	0.0%	0	43	0.0%	0	22	0.0%
	WSO	0	7	0.0%	0	6	0.0%	0	9	0.0%
	All Species	**0**	**130**	**0.0%**	**0**	**481**	**0.0%**	**0**	**354**	**0.0%**
5/29	HCH1	0	49	0.0%	0	206	0.0%	0	273	0.0%
	WCH1	0	33	0.0%	0	53	0.0%	0	40	0.0%
	CHO	0	0	—	0	0	—	0	1	0.0%
	HST	0	100	0.0%	0	185	0.0%	0	155	0.0%
	WST	0	26	0.0%	0	21	0.0%	0	23	0.0%
	WSO	0	7	0.0%	0	6	0.0%	0	17	0.0%
	All Species	**0**	**215**	**0.0%**	**0**	**471**	**0.0%**	**0**	**509**	**0.0%**
5/30	HCH1	0	53	0.0%	0	186	0.0%			—
	WCH1	0	24	0.0%	0	45	0.0%			—
	CHO	0	0	—	0	1	0.0%			—
	HST	0	100	0.0%	0	161	0.0%			—
	WST	0	45	0.0%	0	47	0.0%			—
	WSO	0	4	0.0%	0	11	0.0%			—
	All Species	**0**	**226**	**0.0%**	**0**	**451**	**0.0%**	**0**	**0**	—

1994 Snake River Smolt Monitoring Program Gas Bubble Symptoms

		Lower Granite Dam			Little Goose Dam			Lower Monumental Dam		
Dare	Species	#Obs	#Samp	% GBS	# Obs	# Samp	% GBS	#Obs	# Samp	% GBS
05/27	HCH1	0	24	0.0%	0	59	0.0%	0	164	0.0%
	WCH1	0	4	0.0%	0	14	0.0%	0	18	0.0%
	CHO	—	0	—	—	0	—	—	0	—
	HST	0	31	0.0%	0	100	0.0%	0	129	0.0%
	WST	0	31	0.0%	0	17	0.0%	0	14	0.0%
	WSO	0	4	0.0%	0	8	0.0%	0	3	0.0%
	All Species	**0**	**94**	**0.0%**	**0**	**198**	**0.0%**	**0**	**328**	**0.0%**
05/28	HCH1	0	23	0.0%	0	110	0.0%	0	144	0.0%
	WCH1	0	6	0.0%	0	35	0.0%	0	20	0.0%
	CHO	—	0	—	—	0	—	—	0	—
	HST	0	50	0.0%	0	100	0.0%	0	159	0.0%
	WST	0	44	0.0%	0	35	0.0%	0	22	0.0%
	WSO	0	7	0.0%	0	6	0.0%	0	9	0.0%
	All Species	**0**	**130**	**0.0%**	**0**	**286**	**0.0%**	**0**	**354**	**0.0%**
05/29	HCH1	0	49	0.0%	0	100	0.0%	0	273	0.0%
	WCH1	0	33	0.0%	0	42	0.0%	0	40	0.0%
	CHO	—	0	—	—	0	—	0	1	0.0%
	HST	0	100	0.0%	0	100	0.0%	0	155	0.0%
	WST	0	26	0.0%	0	16	0.0%	0	23	0.0%
	WSO	0	7	0.0%	0	6	0.0%	0	17	0.0%
	All Species	**0**	**215**	**0.0%**	**0**	**264**	**0.0%**	**0**	**509**	**0.0%**
05/30	HCH1	0	53	0.0%	0	100	0.0%	0	134	0.0%
	WCH1	0	24	0.0%	0	37	0.0%	0	21	0.0%
	CHO	—	0	—	0	1	0.0%	0	2	0.0%
	HST	0	100	0.0%	0	100	0.0%	0	79	0.0%
	WST	0	45	0.0%	0	33	0.0%	0	18	0.0%
	WSO	0	4	0.0%	0	11	0.0%	0	1	0.0%
	All Species	**0**	**226**	**0.0%**	**0**	**282**	**0.0%**	**0**	**255**	**0.0%**
05/31	HCH1	0	31	0.0%	0	100	0.0%	0	98	0.0%
	WCH1	0	29	0.0%	0	43	0.0%	0	20	0.0%
	CHO	—	0	—	0	1	0.0%	0	2	0.0%
	HST	0	100	0.0%	0	100	0.0%	0	332	0.0%
	WST	0	50	0.0%	0	60	0.0%	0	52	0.0%
	WSO	0	6	0.0%	0	11	0.0%	—	0	—
	All Species	**0**	**216**	**0.0%**	**0**	**315**	**0.0%**	**0**	**504**	**0.0%**
06/01	HCH1	0	12	0.0%	0	81	0.0%	0	39	0.0%
	WCH1	0	17	0.0%	0	37	0.0%	0	7	0.0%
	CHO	—	0	—	—	0	—	—	0	—
	HST	0	100	0.0%	0	100	0.0%	0	31	0.0%
	WST	0	30	0.0%	0	39	0.0%	0	44	0.0%
	WSO	0	11	0.0%	0	4	0.0%	0	2	0.0%
	All Species	**0**	**170**	**0.0%**	**0**	**261**	**0.0%**	**0**	**123**	**0.0%**
06/02	HCH1	0	13	0.0%	0	34	0.0%			—
	WCH1	0	16	0.0%	0	12	0.0%			—
	CHO	—	0	—	0	1	0.0%			—
	HST	0	53	0.0%	0	101	0.0%			—
	WST	0	7	0.0%	0	17	0.0%			—
	WSO	0	7	0.0%	0	18	0.0%			—
	All Species	**0**	**96**	**0.0%**	**0**	**183**	**0.0%**	**0**	**0**	**—**

1994 Snake River Smolt Monitoring Program Gas Bubble Symptoms

		Lower Granite Dam			Little Goose Dam			Lower Monumental Dam		
Date	Species	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS
06/02	HCH1	0	13	0.0%	0	34	0.0%	0	104	0.0%
	WCH1	0	16	0.0%	0	12	0.0%	0	30	0.0%
	CHO	—	0	—	0	1	0.0%	0	2	0.0%
	HST	0	53	0.0%	0	101	0.0%	0	104	0.0%
	WST	0	7	0.0%	0	17	0.0%	0	9	0.0%
	WSO	0	7	0.0%	0	18	0.0%	0	5	0.0%
	All Species	**0**	**96**	**0.0%**	**0**	**183**	**0.0%**	**0**	**254**	**0.0%**
06/03	HCH1	0	31	0.0%	0	26	0.0%	0	52	0.0%
	WCH1	0	12	0.0%	0	13	0.0%	0	12	0.0%
	CHO	—	0	—	—	0	—	0	2	0.0%
	HST	0	83	0.0%	0	62	0.0%	0	216	0.0%
	WST	0	10	0.0%	0	7	0.0%	0	29	0.0%
	WSO	0	8	0.0%	0	11	0.0%	—	0	—
	All Species	**0**	**144**	**0.0%**	**0**	**119**	**0.0%**	**0**	**311**	**0.0%**
06/04	HCH1	0	90	0.0%	0	37	0.0%	0	14	0.0%
	WCH1	0	50	0.0%	0	10	0.0%	0	6	0.0%
	CHO	—	0	—	—	0	—	0	2	0.0%
	HST	0	266	0.0%	0	52	0.0%	0	58	0.0%
	WST	0	51	0.0%	0	2	0.0%	0	6	0.0%
	WSO	0	9	0.0%	0	9	0.0%	0	1	0.0%
	All Species	**0**	**466**	**0.0%**	**0**	**110**	**0.0%**	**0**	**87**	**0.0%**
06/05	HCH1	0	101	0.0%	0	24	0.0%	0	58	0.0%
	WCH1	0	65	0.0%	0	9	0.0%	0	15	0.0%
	CHO	—	0	—	0	4	0.0%	—	0	—
	HST	0	370	0.0%	0	74	0.0%	0	72	0.0%
	WST	0	92	0.0%	0	12	0.0%	0	7	0.0%
	WSO	0	10	0.0%	0	5	0.0%	—	0	—
	All Species	**0**	**638**	**0.0%**	**0**	**128**	**0.0%**	**0**	**152**	**0.0%**
06/06	HCH1	0	62	0.0%	0	28	0.0%	0	64	0.0%
	WCH1	0	42	0.0%	0	9	0.0%	0	16	0.0%
	CHO	0	1	0.0%	—	0	—	—	0	—
	HST	0	233	0.0%	0	76	0.0%	0	98	0.0%
	WST	0	24	0.0%	0	5	0.0%	0	10	0.0%
	WSO	0	9	0.0%	—	0	—	—	0	—
	All Species	**0**	**371**	**0.0%**	**0**	**118**	**0.0%**	**0**	**188**	**0.0%**
06/07	HCH1	0	41	0.0%	0	27	0.0%			—
	WCH1	0	51	0.0%	0	25	0.0%			—
	CHO	—	0	—	—	0	—			—
	HST	0	39	0.0%	0	35	0.0%			—
	WST	0	15	0.0%	0	5	0.0%			—
	WSO	0	13	0.0%	0	1	0.0%			—
	All Species	**0**	**159**	**0.0%**	**0**	**93**	**0.0%**			—
06/08	HCH1	0	44	0.0%	0	40	0.0%			—
	WCH1	0	51	0.0%	0	23	0.0%			—
	CHO	—	0	—	—	0	—			—
	HST	0	100	0.0%	0	55	0.0%			—
	WST	0	29	0.0%	0	7	0.0%			—
	WSO	0	4	0.0%	0	5	0.0%			—
	All Species	**0**	**228**	**0.0%**	**0**	**130**	**0.0%**	**0**	**0**	—

1994 Snake River Smolt Monitoring Program Gas Bubble Symptoms

		Lower Granite Dam			Little Goose Dam			Lower Monumental Dam		
Date	Species	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS
06/07	HCH1	0	41	0.0%	0	27	0.0%	0	52	0.0%
	WCH1	0	51	0.0%	0	25	0.0%	0	13	0.0%
	CHO	---	0	---	---	0	---	0	3	0.0%
	HST	0	39	0.0%	0	35	0.0%	0	55	0.0%
	WST	0	15	0.0%	0	5	0.0%	0	10	0.0%
	WSO	0	13	0.0%	0	1	0.0%	0	1	0.0%
	All Species	**0**	**159**	**0.0%**	**0**	**93**	**0.0%**	**0**	**134**	**0.0%**
06/08	HCH1	0	44	0.0%	0	40	0.0%	0	34	0.0%
	WCH1	0	51	0.0%	0	23	0.0%	0	15	0.0%
	CHO	---	0	---	---	0	---	0	3	0.0%
	HST	0	100	0.0%	0	55	0.0%	0	39	0.0%
	WST	0	29	0.0%	0	7	0.0%	0	1	0.0%
	WSO	0	4	0.0%	0	5	0.0%	0	1	0.0%
	All Species	**0**	**228**	**0.0%**	**0**	**130**	**0.0%**	**0**	**93**	**0.0%**
06/09	HCH1	0	27	0.0%	0	42	0.0%	0	30	0.0%
	WCH1	0	37	0.0%	0	42	0.0%	0	10	0.0%
	CHO	---	0	---	0	4	0.0%	0	1	0.0%
	HST	0	100	0.0%	0	75	0.0%	0	70	0.0%
	WST	0	25	0.0%	0	5	0.0%	0	10	0.0%
	WSO	0	4	0.0%	0	6	0.0%	0	1	0.0%
	All Species	**0**	**193**	**0.0%**	**0**	**174**	**0.0%**	**0**	**122**	**0.0%**
06/10	HCH1	0	3	0.0%	0	44	0.0%	0	6	0.0%
	WCH1	0	20	0.0%	0	24	0.0%	0	3	0.0%
	CHO	0	1	0.0%	---	0	---	---	0	---
	HST	0	74	0.0%	0	100	0.0%	0	24	0.0%
	WST	0	7	0.0%	0	6	0.0%	0	1	0.0%
	WSO	0	1	0.0%	0	4	0.0%	---	0	---
	All Species	**0**	**106**	**0.0%**	**0**	**178**	**0.0%**	**0**	**34**	**0.0%**
06/11	HCH1	0	3	0.0%	0	24	0.0%	0	29	0.0%
	WCH1	0	5	0.0%	0	24	0.0%	0	4	0.0%
	CHO	---	0	---	0	1	0.0%	0	4	0.0%
	HST	0	54	0.0%	0	101	0.0%	0	104	0.0%
	WST	0	4	0.0%	0	13	0.0%	0	6	0.0%
	WSO	0	2	0.0%	0	3	0.0%	0	1	0.0%
	All Species	**0**	**68**	**0.0%**	**0**	**166**	**0.0%**	**0**	**148**	**0.0%**
06/12	HCH1	0	11	0.0%	0	36	0.0%			---
	WCH1	0	13	0.0%	0	15	0.0%			---
	CHO	---	0	---	0	2	0.0%			---
	HST	0	50	0.0%	0	100	0.0%			---
	WST	0	5	0.0%	0	20	0.0%			---
	WSO	---	0	---	0	4	0.0%			---
	All Species	**0**	**79**	**0.0%**	**0**	**177**	**0.0%**	**0**	**0**	**---**
06/13	HCH1	0	15	0.0%	0	12	0.0%			---
	WCH1	0	12	0.0%	0	16	0.0%			---
	CHO	---	0	---	0	1	0.0%			---
	HST	0	66	0.0%	0	100	0.0%			---
	WST	0	5	0.0%	0	20	0.0%			---
	WSO	0	7	0.0%	0	2	0.0%			---
	All Species	**0**	**105**	**0.0%**	**0**	**151**	**0.0%**	**0**	**0**	**---**

1994 Snake River Smolt Monitoring Program Gas Bubble Symptoms

		Lower Granite Dam			Little Goose Dam			Lower Monumental Dam		
Date	Species	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS
06/14	HCH1	0	30	0.0%	0	31	0.0%	0	40	0.0%
	WCH1	0	21	0.0%	0	19	0.0%	0	16	0.0%
	CHO	0	1	0.0%	0	1	0.0%	0	5	0.0%
	HST	0	44	0.0%	0	44	0.0%	0	27	0.0%
	WST	0	2	0.0%	0	7	0.0%	0	4	0.0%
	WSO	0	4	0.0%	0	7	0.0%	0	2	0.0%
	All Species	**0**	**102**	**0.0%**	**0**	**109**	**0.0%**	**0**	**94**	**0.0%**
06/15	HCH1	0	32	0.0%	0	33	0.0%	0	56	0.0%
	WCH1	0	34	0.0%	0	22	0.0%	0	17	0.0%
	CHO	0	1	0.0%	0	1	0.0%	0	5	0.0%
	HST	0	100	0.0%	0	59	0.0%	0	70	0.0%
	WST	0	24	0.0%	0	5	0.0%	0	6	0.0%
	WSO	0	4	0.0%	0	4	0.0%	0	4	0.0%
	All Species	**0**	**195**	**0.0%**	**0**	**124**	**0.0%**	**0**	**158**	**0.0%**
06/16	HCH1	0	38	0.0%	0	31	0.0%	0	17	0.0%
	WCH1	0	59	0.0%	0	40	0.0%	0	7	0.0%
	CHO	0	1	0.0%	0	1	0.0%	0	1	0.0%
	HST	0	582	0.0%	0	100	0.0%	0	175	0.0%
	WST	0	51	0.0%	0	12	0.0%	0	10	0.0%
	WSO	0	19	0.0%	0	17	0.0%	0	3	0.0%
	All Species	**0**	**750**	**0.0%**	**0**	**201**	**0.0%**	**0**	**213**	**0.0%**
06/17	HCH1	0	87	0.0%	0	22	0.0%	0	48	0.0%
	WCH1	0	114	0.0%	0	16	0.0%	0	12	0.0%
	CHO	0	2	0.0%	—	0	—	0	4	0.0%
	HST	0	1,506	0.0%	0	100	0.0%	0	180	0.0%
	WST	0	133	0.0%	0	17	0.0%	0	17	0.0%
	WSO	0	12	0.0%	0	6	0.0%	0	3	0.0%
	All Species	**0**	**1,854**	**0.0%**	**0**	**161**	**0.0%**	**0**	**264**	**0.0%**
06/18	HCH1	0	37	0.0%	0	39	0.0%	0	59	0.0%
	WCH1	0	63	0.0%	0	37	0.0%	0	17	0.0%
	CHO	—	0	—	—	0	—	0	29	0.0%
	HST	0	100	0.0%	0	100	0.0%	0	418	0.0%
	WST	0	57	0.0%	0	15	0.0%	0	37	0.0%
	WSO	0	7	0.0%	0	4	0.0%	0	6	0.0%
	All Species	**0**	**264**	**0.0%**	**0**	**195**	**0.0%**	**0**	**566**	**0.0%**
06/19	HCH1	0	32	0.0%	0	19	0.0%	0	84	0.0%
	WCH1	0	68	0.0%	0	31	0.0%	0	49	0.0%
	CHO	0	2	0.0%	—	0	—	0	18	0.0%
	HST	0	332	0.0%	0	100	0.0%	0	265	0.0%
	WST	0	40	0.0%	0	6	0.0%	0	31	0.0%
	WSO	0	28	0.0%	—	0	—	0	6	0.0%
	All Species	**0**	**502**	**0.0%**	**0**	**156**	**0.0%**	**0**	**453**	**0.0%**
06/20	HCH1	0	22	0.0%	0	11	0.0%			—
	WCH1	0	77	0.0%	0	15	0.0%			—
	CHO	—	0	—	—	0	—			—
	HST	0	100	0.0%	0	100	0.0%			—
	WST	0	78	0.0%	0	19	0.0%			—
	WSO	0	33	0.0%	0	8	0.0%			—
	All Species	**0**	**310**	**0.0%**	**0**	**153**	**0.0%**	**0**	**0**	**—**

1994 Snake River Smolt Monitoring Program Gas Bubble Symptoms

		Lower Granite Dam			Little Goose Dam			Lower Monumental Dam		
Date	Species	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS
06/18	HCH1	0	37	0.0%	0	39	0.0%	0	59	0.0%
	WCH1	0	63	0.0%	0	37	0.0%	0	17	0.0%
	CHO	—	0	—	—	0	—	0	29	0.0%
	HST	0	100	0.0%	0	100	0.0%	0	418	0.0%
	WST	0	57	0.0%	0	15	0.0%	0	37	0.0%
	WSO	0	7	0.0%	0	4	0.0%	0	6	0.0%
	All Species	**0**	**264**	**0.0%**	**0**	**195**	**0.0%**	**0**	**566**	**0.0%**
06/19	HCH1	0	32	0.0%	0	19	0.0%	0	84	0.0%
	WCH1	0	68	0.0%	0	31	0.0%	0	49	0.0%
	CHO	0	2	0.0%	—	0	—	0	18	0.0%
	HST	0	332	0.0%	0	100	0.0%	0	265	0.0%
	WST	0	40	0.0%	0	6	0.0%	0	31	0.0%
	WSO	0	28	0.0%	—	0	—	0	6	0.0%
	All Species	**0**	**502**	**0.0%**	**0**	**156**	**0.0%**	**0**	**453**	**0.0%**
06/20	HCH1	0	22	0.0%	0	11	0.0%	0	67	0.0%
	WCH1	0	77	0.0%	0	15	0.0%	0	25	0.0%
	CHO	—	0	—	—	0	—	0	15	0.0%
	HST	0	100	0.0%	0	100	0.0%	0	567	0.0%
	WST	0	78	0.0%	0	19	0.0%	0	39	0.0%
	WSO	0	33	0.0%	0	8	0.0%	0	2	0.0%
	All Species	**0**	**310**	**0.0%**	**0**	**153**	**0.0%**	**0**	**715**	**0.0%**
06/21	HCH1	0	19	0.0%	0	14	0.0%	0	54	0.0%
	WCH1	0	81	0.0%	0	18	0.0%	0	30	0.0%
	CHO	0	3	0.0%	0	2	0.0%	0	19	0.0%
	HST	0	100	0.0%	0	100	0.0%	0	553	0.0%
	WST	0	86	0.0%	0	17	0.0%	0	48	0.0%
	WSO	0	40	0.0%	0	4	0.0%	0	6	0.0%
	All Species	**0**	**329**	**0.0%**	**0**	**155**	**0.0%**	**0**	**710**	**0.0%**
06/22	HCH1	0	112	0.0%	0	11	0.0%	0	24	0.0%
	WCH1	0	147	0.0%	0	10	0.0%	0	10	0.0%
	CHO	0	3	0.0%	—	0	—	0	7	0.0%
	HST	0	100	0.0%	0	100	0.0%	0	241	0.0%
	WST	0	92	0.0%	0	14	0.0%	0	18	0.0%
	WSO	0	31	0.0%	0	8	0.0%	—	0	—
	All Species	**0**	**485**	**0.0%**	**0**	**143**	**0.0%**	**0**	**300**	**0.0%**
06/23	HCH1	0	34	0.0%	0	14	0.0%	0	36	0.0%
	WCH1	0	39	0.0%	0	6	0.0%	0	12	0.0%
	CHO	—	0	—	0	1	0.0%	0	14	0.0%
	HST	0	100	0.0%	0	100	0.0%	0	440	0.0%
	WST	0	100	0.0%	0	32	0.0%	0	20	0.0%
	WSO	0	38	0.0%	0	6	0.0%	0	1	0.0%
	All Species	**0**	**311**	**0.0%**	**0**	**159**	**0.0%**	**0**	**523**	**0.0%**
06/24	HCH1			—			—			—
	WCH1			—			—			—
	CHO			—			—			—
	HST			—			—			—
	WST			—			—			—
	WSO			—			—			—
	All Species	**0**	**0**	**—**	**0**	**0**	**—**	**0**	**0**	**—**

1994 Snake River Smolt Monitoring Program Gas Bubble Symptoms

		Lower Granite Dam			Little Goose Dam			Lower Monumental Dam		
Date	Species	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS
06/25	HCH1			—			—	0	15	0.0%
	WCH1			—			—	0	9	0.0%
	CHO			—			—	0	8	0.0%
	HST			—			—	0	61	0.0%
	WST			—			—	0	5	0.0%
	WSO			—			—	0	2	0.0%
	All Species	**0**	**0**	**—**	**0**	**0**	**—**	**0**	**100**	**0.0%**
06/26	HCH1			—			—	0	13	0.0%
	WCH1			—			—	0	5	0.0%
	CHO			—			—	0	10	0.0%
	HST			—			—	0	49	0.0%
	WST			—			—	0	1	0.0%
	WSO			—			—	—	0	—
	All Species	**0**	**0**	**—**	**0**	**0**	**—**	**0**	**78**	**0.0%**
06/27	HCH1	0	55	0.0%	0	9	0.0%	0	21	0.0%
	WCH1	0	115	0.0%	0	8	0.0%	0	4	0.0%
	CHO	0	60	0.0%	—	0	—	0	7	0.0%
	HST	0	100	0.0%	0	51	0.0%	0	65	0.0%
	WST	0	48	0.0%	0	4	0.0%	0	7	0.0%
	WSO	0	20	0.0%	0	6	0.0%	—	0	—
	All Species	**0**	**398**	**0.0%**	**0**	**78**	**0.0%**	**0**	**104**	**0.0%**
06/28	HCH1			—			—			—
	WCH1			—			—			—
	CHO			—			—			—
	HST			—			—			—
	WST			—			—			—
	WSO			—			—			—
	All Species	**0**	**0**	**—**	**0**	**0**	**—**	**0**	**0**	**—**
06/29	HCH1	0	45	0.0%	0	14	0.0%			—
	WCH1	0	183	0.0%	0	8	0.0%			—
	CHO	0	72	0.0%	—	0	—			—
	HST	0	99	0.0%	0	100	0.0%			—
	WST	0	75	0.0%	0	15	0.0%			—
	WSO	0	17	0.0%	0	8	0.0%			—
	All Species	**0**	**491**	**0.0%**	**0**	**145**	**0.0%**	**0**	**0**	**—**
06/30	HCH1			—			—	0	12	0.0%
	WCH1			—			—	0	4	0.0%
	CHO			—			—	0	3	0.0%
	HST			—			—	0	45	0.0%
	WST			—			—	0	3	0.0%
	WSO			—			—	0	3	0.0%
	All Species	**0**	**0**	**—**	**0**	**0**	**—**	**0**	**70**	**0.0%**
07/01	HCH1	0	4	0.0%	0	5	0.0%			—
	WCH1	0	8	0.0%	0	5	0.0%			—
	CHO	0	2	0.0%	—	0	—			—
	HST	0	82	0.0%	0	78	0.0%			—
	WST	0	4	0.0%	0	5	0.0%			—
	WSO	0	5	0.0%	0	3	0.0%			—
	All Species	**0**	**105**	**0.0%**	**0**	**96**	**0.0%**	**0**	**0**	**—**

1994 SMP EXTERNAL GBS SEPARATOR SAMPLES

*McNary is unable to differentiate hatchery and wild chinook

	MCNARY DAM*			LITTLE GOOSE DAM			LOWER MONUMENTAL		
	# OBS	# SAM	% GBS	# OBS	# SAM	% GBS	# OBS	# SAM	% GBS
05/18 HCH1 A M				0	45				
HCH1 PM				0	48				
TOTA	0	0	—	0	93	0.0%	0	0	—
WCH1 AM				0	5				
WCH1 PM				0	4				
TOTA	0	0	—	0	9	0.0%	0	0	—
HST AM				0	50				
HST PM				0	55				
TOTA	0	0	—	0	105	0.0%	0	0	—
WST AU									
wsr PM									
TOTA	0	0	—	0	0	—	0	0	—
GRAND TOTAI	0	0	—	0	207	0.0%	0	0	—
05/19 HCHI AM				0	43		0	50	
HCH1 PM				0	49		1	47	
TOTA	0	0	—	0	92	0.0%	1	97	1.0%
WCH1 AM							0	46	
WCH1 PM				0	2		0	2	
TOTAI	0	0	—	0	2	0.0%	0	48	0.0%
HST AM				0	45				
HST PM				0	50		1	49	
TOTAI	0	0	—	0	95	0.0%	1	49	2.0%
WST AM				0	5		0	4	
WST PM							0	1	
TOTAI	0	0	—	0	5	0.0%	0	5	0.0%
GRAND TOTAL	0	0	—	0	194	0.0%	2	199	1.0%
05/20 HCHI AM	0	50		0	44		0	44	
HCH, PM	0	50		0	48		0	48	
TOTAI	0	100	0.0%	0	92	0.0%	0	92	0.0%
WCH1 AM				0	6		0	6	
WCH, PM				0	2		0	2	
TOTAI			—	0	8	0.0%	0	8	0.0%
HST AM	0	50		0	51		2	47	
HST PM	0	39		0	46		0	48	
TOTAL	0	89	0.0%	0	97	0.0%	2	95	2.1%
WST AM	—	0					0	3	
WST PM	0	11		0	4		0	2	
TOTAL	0	11	0.0%	0	4	0.0%	0	5	0.0%
GRAND TOTAL	0	200	0.0%	0	201	0.0%	2	200	1.0%
05/21 HCH1 A M	1	50		0	45		1	48	
HCH1 PM	0	50		0	51		0	39	
TOTAL	1	100	1.0%	0	96	0.0%	1	87	1.1%
WCH1 AM				0	5		0	2	
WCH1 PM				0	2		0	11	
TOTAL	0	0	—	0	7	0.0%	0	13	0.0%
HST AM	0	40		0	51		1	46	
H S T P M	0	38		0	51		3	49	
TOTAL	0	78	0.0%	0	102	0.0%	4	95	4.2%
WST AM	0	10		0	1		1	4	
WST PM	0	12		0	2		0	1	
TOTAL	0	22	0.0%	0	3	0.0%	1	5	20.0%
GRAND TOTAL	1	200	0.5%	0	208	0.0%	6	200	3.0%
05/22 HCH1 A M	0	50		0	50		0	48	
HCHI PM	0	50		0	55		2	44	
TOTAL	0	100	0.0%	0	105	0.0%	2	92	2.2%
WCH1 AM				0	1		0	2	
WCH1 PM				0	5		0	6	
TOTAL	0	0	—	0	6	0.0%	0	8	0.0%
HST AM	0	44		0	44		2	48	
HST PM	0	44		0	55		0	49	
TOTAL	0	88	0.0%	0	99	0.0%	2	97	2.1%
WST AM	0	6		0	5		0	2	
WST PM	0	6		0	2		0	1	
TOTAI	0	12	0.0%	0	7	0.0%	0	3	0.0%
GRAND TOTAL	0	200	0.0%	0	217	0.0%	4	200	2.0%

1994 SMP EXTERNAL GBS SEPARATOR SAMPLES

	MCNARY DAM*			LITTLE GOOSE DAM			LOWER MONUMENTAL		
	# OBS	# SAM	% GBS	# OBS	# SAM	% GBS	# OBS	# SAM	% GBS
05/23 HCHI AM	0	50		0	45		1	39	
HCH1 PM	0	50		0	46		1	46	
TOTAL	0	100	0.0%	0	91	0.0%	2	85	2.4%
WCHI AM				0	2		0	11	
WCHI PM				0	4		0	4	
TOTAL	0	0	—	0	6	0.0%	0	15	0.0%
HST AN	0	44		0	49		1	43	
HST PM	0	38		0	48		0	48	
TOTAL	0	82	0.0%	0	97	0.0%	1	91	1.1%
WST AM	0	6		0	1		0	7	
WST P M	0	12		0	2		0	2	
TOTAL	0	18	0.0%	0	3	0.0%	0	9	0.0%
GRAND TOTAL	0	200	0.0%	0	197	0.0%	3	200	1.5%
05/24 HCH1 A M	0	50		0	45		0	43	
HCH1 PM	0	50		0	20		0	47	
TOTAL	0	100	0.0%	0	65	0.0%	0	90	0.0%
WCH1 AM				0	2		0	7	
WCH1 PM				0	3		0	3	
TOTAL	0	0	—	0	5	0.0%	0	10	0.0%
HST AM	0	49		0	46		2	42	
HST PM	0	48		0	47		0	50	
TOTAL	0	97	0.0%	0	93	0.0%	2	92	2.2%
WST AM	0	1		0	2		0	8	
WST PM	0	2		0	4				
TOTAL	0	3	0.0%	0	6	0.0%	0	8	0.0%
GRAND TOTAL	0	200	0.0%	0	169	0.0%	2	200	1.0%
05/25 HCH, AM	0	50		0	28		0	47	
HCH1 PM	0	50		0	25		0	48	
TOTAL	0	100	0.0%	0	53	0.0%	0	95	0.0%
WCH1 AM				0	2		0	3	
WCH1 PM				0	5		0	2	
TOTAL	0	0	—	0	7	0.0%	0	5	0.0%
HST AM	0	46		0	55		0	48	
HST PM	0	50		0	56		0	48	
TOTAL	0	96	0.0%	0	111	0.0%	0	96	0.0%
WST AM	0	4		0	8		0	2	
WST PM	0	3		0	2		0	2	
TOTAL	0	7	0.0%	0	10	0.0%	0	4	0.0%
GRAND TOTAL	0	203	0.0%	0	181	0.0%	0	200	0.0%
05/26 HCH1 A M	0	50		0	13		0	39	
HCHI PM				0	52		0	47	
TOTAL	0	50	0.0%	0	65	0.0%	0	86	0.0%
WCH1 AM							0	11	
WCH1 PM				0	15		0	3	
TOTAL	0	0	—	0	15	0.0%	0	14	0.0%
HST AM	0	43		0	56		0	46	
HST PM				0	59		0	46	
TOTAL	0	43	0.0%	0	115	0.0%	0	92	0.0%
WST AM	0	7		0	10		0	4	
WST PM				0	4		0	4	
TOTAL	0	7	0.0%	0	14	0.0%	0	8	0.0%
GRAND TOTAL	0	100	0.0%	0	209	0.0%	0	200	0.0%
05/27 HCHI AM	0	50		0	45		0	46	
HCHI PM	0	50					0	42	
TOTAL	0	100	0.0%	0	45	0.0%	0	88	0.0%
WCH1 AM				0	3		0	4	
WCH1 PM							0	8	
TOTAL	0	0	—	0	3	0.0%	0	12	0.0%
HST A M	1	49		0	43		0	46	
HST PM	0	46					0	45	
TOTAL	1	95	1.1%	0	43	0.0%	0	91	0.0%
WST AM	0	3		0	5		0	4	
WST PM	0	4					0	5	
TOTAL	0	7	0.0%	0	5	0.0%	0	9	0.0%
GRAND TOTAL	1	202	0.5%	0	96	0.0%	0	200	0.0%

1994 SMP EXTERNAL GBS SEPARATOR SAMPLES

*McNary is unable to differentiate hatchery and wild chinook

	MCNARY DAM*			LITTLE GOOSE DAM			LOWER MONUMENTAL		
	# OBS	# SAM	% GBS	# OBS	# SAM	% GBS	# OBS	# SAM	% GBS
05/28 HCH1 A M	0	50		0	40		0	46	
HCHI PM	0	50		0	63		0	39	
TOTAI	0	100	0.0%	0	103	0.0%	0	85	0.0%
WCH1 AM				0	7		0	4	
WCH1 PM				0	6		0	11	
TOTAI			—	0	13	0.0%	0	15	0.0%
HST AM	0	49		0	45		0	45	
HST PM	0	45		0	40		0	48	
TOTAI	0	94	0.0%	0	85	0.0%	0	93	0.0%
WST AM	0	1		0	6		0	5	
WST PM	1	5		0	1		0	2	
TOTAI	1	6	16.7%	0	7	0.0%	0	7	0.0%
GRAND TO'	1	200	0.5%	0	208	0.0%	0	200	0.0%
05/29 HCH1 A M	0	50		0	43		0	43	
HCHI PM	0	50		0	45		0	41	
TOTAL	0	100	0.0%	0	88	0.0%	0	84	0.0%
WCH1 AM				0	5		0	7	
WCH1 PM				0	3		0	9	
TOTAL			—	0	8	0.0%	0	16	0.0%
HST AM	0	48		0	45		0	48	
HST PM	0	48		0	21		0	47	
TOTAL	0	96	0.0%	0	66	0.0%	0	95	0.0%
WST AM	0	2		0	4		0	2	
WST PM	0	2		0	3		0	3	
TOTAL	0	4	0.0%	0	7	0.0%	0	5	0.0%
GRAND TO	0	200	0.0%	0	169	0.0%	0	200	0.0%
05/30 HCHI AM	0	50		0	41		0	48	
HCHI PM	0	50		0	32		0	37	
TOTAL	0	100	0.0%	0	73	0.0%	0	85	0.0%
WCH1 AM				0	5		0	2	
WCH1 PM				0	2		0	13	
TOTAL			—	0	7	0.0%	0	15	0.0%
HST AM	1	48		0	40		0	47	
HST PM	1	43		0	23		0	49	
TOTAL	2	91	2.2%	0	63	0.0%	0	96	0.0%
WST A M	0	2		0	11		0	3	
WST PM	0	7		—	0		0	1	
TOTAL	0	9	0.0%	0	11	0.0%	0	4	0.0%
GRAND TO'	2	200	1.0%	0	154	0.0%	0	200	0.0%
05/31 HCH, AM	0	50		0	42		0	43	
HCHI PM	0	50		0	39		0	40	
TOTAL	0	100	0.0%	0	81	0.0%	0	83	0.0%
WCH, AM				0	6		0	7	
WCH1 PM				0	1		0	10	
TOTAL			—	0	7	0.0%	0	17	0.0%
H S T A M	0	48		0	39		0	44	
HST PM	0	49		0	55		0	49	
TOTAL	0	97	0.0%	0	94	0.0%	0	93	0.0%
WST AM	0	2		0	9		0	6	
WST PM	0	1		0	3		0	1	
TOTAL	0	3	0.0%	0	12	0.0%	0	7	0.0%
GRAND TO'	0	200	0.0%	0	194	0.0%	0	200	0.0%
06/01 HCH1 A M	0	50		0	2		0	34	
HCH1 PM	0	50		0	25		0	10	
TOTAL	0	100	0.0%	0	27	0.0%	0	44	0.0%
WCH1 AM				0	1		0	3	
WCH1 PM				0	8		0	8	
TOTAL	—	—	—	0	9	0.0%	0	11	0.0%
HST AM	0	46		0	50		0	44	
HST PM	0	45		0	60		0	20	
T O T A L	0	91	0.0%	0	110	0.0%	0	64	0.0%
WST AM	0	4		0	3		0	1	
WST PM	0	5		0	5		0	7	
TOTAL	0	9	0.0%	0	8	0.0%	0	8	0.0%
GRAND TO'	0	200	0.0%	0	154	0.0%	0	127	0.0%

1994 Smolt Monitoring Program Gas Bubble Symptoms from Separator Samples

Date	Species / Sample Tie	McNary Dam* # Obs	McNary Dam* # Samp	McNary Dam* % GBS	Little Goose Dam # Obs	Little Goose Dam # Samp	Little Goose Dam % GBS	Lower Monumental Dam # Obs	Lower Monumental Dam # Samp	Lower Monumental Dam % GBS
06/01	HCH1 AM	0	50		0	2		0	34	
	HCH1 PM	0	50		0	25		0	10	
	TOTAL	0	100	0.0%	0	27	0.0%	0	44	0.0%
	WCH1 AM				0	1		0	3	
	WCH1 PM				0	8		0	8	
	TOTAL	—	—	—	0	9	0.0%	0	11	0.0%
	HST AM	0	46		0	50		0	44	
	HST PM	0	45		0	60		0	20	
	TOTAL	0	91	0.0%	0	110	0.0%	0	64	0.0%
	WST AM	0	4		0	3		0	1	
	WST PM	0	5		0	5		0	7	
	TOTAL	0	9	0.0%	0	8	0.0%	0	8	0.0%
	GRAND TOTAL	**0**	**200**	**0.0%**	**0**	**154**	**0.0%**	**0**	**127**	**0.0%**
06/02	HCH1 AM	0	50		0	1		0	16	
	HCH1 PM	0	50		0	19		0	13	
	TOTAL	0	100	0.0%	0	20	0.0%	0	29	0.0%
	WCH1 AM				—	0		0	3	
	WCH1 PM				0	6		0	3	
	TOTAL	—	—	—	0	6	0.0%	0	6	0.0%
	HST AM	0	47		0	27		0	50	
	HST PM	0	45		0	12		0	23	
	TOTAL	0	92	0.0%	0	39	0.0%	0	73	0.0%
	WST AM	0	3		0	2		—	0	
	WST PM	0	5		0	2		0	2	
	TOTAL	0	8	0.0%	0	4	0.0%	0	2	0.0%
	GRAND TOTAL	**0**	**200**	**0.0%**	**0**	**69**	**0.0%**	**0**	**110**	**0.0%**
06/03	HCH1 AM	0	50		0	9		0	17	
	HCH1 PM	0	50		0	4		0	4	
	TOTAL	0	100	0.0%	0	13	0.0%	0	21	0.0%
	WCH1 AM				0	1		0	2	
	WCH1 PM				0	2		0	1	
	TOTAL	—	—	—	0	3	0.0%	0	3	0.0%
	HST AM	0	46		0	25		0	49	
	HST PM	1	45		0	13		0	17	
	TOTAL.	1	91	1.1%	0	38	0.0%	0	66	0.0%
	WST AM	0	4		0	2		0	1	
	WST PM	0	5		—	0		0	3	
	TOTAL	0	9	0.0%	0	2	0.0%	0	4	0.0%
	GRAND TOTAL	**1**	**200**	**0.5%**	**0**	**56**	**0.0%**	**0**	**94**	**0.0%**
06/04	HCH1 AM	0	50		0	8		0	3	
	HCH1 PM	0	50		0	4		0	1	
	TOTAL	0	100	0.0%	0	12	0.0%	0	4	0.0%
	WCH1 AM				0	1		—	0	
	WCH1 PM				—	0		0	1	
	TOTAL	—	—	—	0	1	0.0%	0	1	0.0%
	HST AM	0	47		0	35		0	31	
	HST PM	0	44		0	4		0	15	
	TOTAL	0	91	0.0%	0	39	0.0%	0	46	0.0%
	WST AM	0	3		0	2		0	2	
	WST PM	0	6		0	1		—	0	
	TOTAL	0	9	0.0%	0	3	0.0%	0	2	0.0%
	GRAND TOTAL	**0**	**200**	**0.0%**	**0**	**55**	**0.0%**	**0**	**53**	**0.0%**

1994 Smolt Monitoring Program Gas Bubble Symptoms from Separator Samples

		McNary Dam*			Little Goose Dam			Lower Monumental Dam		
Date	Species I Sample Tie	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS
06/05	HCH1 AM	0	50		0	6		0	41	
	HCH1 PM	0	50		0	26		0	7	
	TOTAL	0	100	0.0%	0	32	0.0%	0	48	0.0%
	WCH1 AM				0	1		0	9	
	WCH1 PM				0	8		0	2	
	TOTAL	—	—	—	0	9	0.0%	0	11	0.0%
	HST AM	0	48		0	49		0	46	
	HST PM	0	46		0	16		0	13	
	TOTAL	0	94	0.0%	0	65	0.0%	0	59	0.0%
	WST AM	0	2		0	6		0	4	
	WST PM	0	4		0	4		0	2	
	TOTAL	0	6	0.0%	0	10	0.0%	0	6	0.0%
	GRAND TOTAL	**0**	**200**	**0.0%**	**0**	**116**	**0.0%**	**0**	**124**	**0.0%**
06/06	HCH1 AM	0	50		0	6		0	25	
	HCH1 PM	0	50		0	11		0	8	
	TOTAL	0	100	0.0%	0	17	0.0%	0	33	0.0%
	WCH1 AM				0	3		0	4	
	WCH1 PM				0	5		0	8	
	TOTAL	—	—	—	0	8	0.0%	0	12	0.0%
	HST AM	0	46		0	20		0	23	
	HST PM	0	49		0	9		0	16	
	TOTAL	0	95	0.0%	0	29	0.0%	0	39	0.0%
	WST AM	0	4		0	1		0	2	
	WST PM	0	1		—	0		0	1	
	TOTAL	0	5	0.0%	0	1	0.0%	0	3	0.0%
	GRAND TOTAL	**0**	**200**	**0.0%**	**0**	**55**	**0.0%**	**0**	**87**	**0.0%**
06/07	HCH1 AM	0	50		0	13				
	HCH1 PM				0	2				
	TOTAL	0	50	0.0%	0	15	0.0%	0	0	—
	WCH1 AM				0	3				
	WCH1 PM				0	5				
	TOTAL	—	—	—	0	8	0.0%	0	0	—
	HST AM	0	48		0	18				
	HST PM				0	6				
	TOTAL	0	48	0.0%	0	24	0.0%	0	0	—
	WST AM	0	2		0	3				
	WST PM				0	1				
	TOTAL	0	2	0.0%	0	4	0.0%	0	0	—
	GRAND TOTAL	**0**	**100**	**0.0%**	**0**	**51**	**0.0%**	**0**	**0**	—

* Chinook not differentiated by rearing type at McNary Dam; all chinook tabulated in Hatchery category.

1994 Smolt Monitoring Program Gas Bubble Symptoms from Separator Samples

Date	Species / Sample Time	McNary Dam* # Obs	McNary Dam* # Samp	McNary Dam* % GBS	Little Goose Dam # Obs	Little Goose Dam # Samp	Little Goose Dam % GBS	Lower Monumental Dam # Obs	Lower Monumental Dam # Samp	Lower Monumental Dam % GBS
)6/08	HCH1 AM				0	3		0	4	
	HCH1 P M	0	50		0	3		0	4	
	TOTAL	0	50	0.0%	0	6	0.0%	0	8	0.0%
	WCH1 AM				0	1		0	1	
	WCH1 P M				0	1		0	1	
	TOTAL	—	—	—	0	2	0.0%	0	2	0.0%
	HST AM				0	9		0	9	
	HST PM	0	46		0	4		0	3	
	TOTAL	0	46	0.0%	0	13	0.0%	0	12	0.0%
	WST AM							0	1	
	WST PM	0	4							
	TOTAL	0	4	0.0%	0	0	—	0	1	0.0%
	GRAND TOTAL	**0**	**100**	**0.0%**	**0**	**21**	**0.0%**	**0**	**23**	**0.0%**
)6/09	HCH1 AM	0	50		0	8		0	4	
	HCH1 PM	0	50					0	1	
	TOTAL	0	100	0.0%	0	8	0.0%	0	5	0.0%
	WCH1 AM				0	2		0	1	
	WCH1 P M				0	1		0	1	
	TOTAL	—	—	—	0	3	0.0%	0	2	0.0%
	HST AM	0	46		0	16		0	8	
	HST PM	0	45		0	3		0	3	
	TOTAL	0	91	0.0%	0	19	0.0%	0	11	0.0%
	WST AM	0	4		0	2		0	2	
	WST PM	0	5					0	1	
	TOTAL	0	9	0.0%	0	2	0.0%	0	3	0.0%
	GRAND TOTAL	**0**	**200**	**0.0%**	**0**	**32**	**0.0%**	**0**	**21**	**0.0%**
)6/10	HCH1 AM	0	50		0	8		0	4	
	HCH1 PM	0	50					0	2	
	TOTAL	0	100	0.0%	0	8	0.0%	0	6	0.0%
	WCH1 AM				0	4		0	2	
	WCH1 PM				0	1		0	1	
	TOTAL	—	—	—	0	5	0.0%	0	3	0.0%
	HST AM	1	46		0	24		0	11	
	HST PM	0	45		0	6		0	13	
	TOTAL	1	91	1.1%	0	30	0.0%	0	24	0.0%
	WST AM	0	4					0	1	
	WST PM	0	5		0	2				
	TOTAL	0	9	0.0%	0	2	0.0%	0	1	0.0%
	GRAND TOTAL	**1**	**200**	**0.5%**	**0**	**45**	**0.0%**	**0**	**34**	**0.0%**
)6/11	HCH1 AM	0	50					0	7	
	HCH1 P M	0	50					0	1	
	TOTAL	0	100	0.0%	0	0	—	0	8	0.0%
	WCH1 AM				0	2		0	5	
	WCH1 PM							0	1	
	TOTAL	—	—	—	0	2	0.0%	0	6	0.0%
	HST AM	0	47		0	42		0	30	
	HST PM	0	46		0	12		0	6	
	TOTAL	0	93	0.0%	0	54	0.0%	0	36	0.0%
	WST AM	0	3		0	1		0	1	
	WST PM	0	4					0	1	
	TOTAL	0	7	0.0%	0	1	0.0%	0	2	0.0%
	GRAND TOTAL	**0**	**200**	**0.0%**	**0**	**57**	**0.0%**	**0**	**52**	**0.0%**

1994 Smolt Monitoring Program Gas Bubble Symptoms from Separator Samples

		McNary Dam*			Little Goose Dam			Lower Monumental Dam		
Date	Species / Sample Time	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS
06/12	HCH1 AM	0	50		0	3		0	4	
	HCH1 PM	0	50					0	3	
	TOTAL	0	100	0.0%	0	3	0.0%	0	7	0.0%
	WCH1 AM							0	1	
	WCH1 PM									
	TOTAL	—	—	—	0	0	—	0	1	0.0%
	HST AM	0	46		0	32		0	7	
	HST PM	0	48		0	14		0	5	
	TOTAL	0	94	0.0%	0	46	0.0%	0	12	0.0%
	WST AM	0	4					0	1	
	WST PM	0	2		0	1		0	1	
	TOTAL	0	6	0.0%	0	1	0.0%	0	2	0.0%
	GRAND TOTAL	**0**	**200**	**0.0%**	**0**	**50**	**0.0%**	**0**	**22**	**0.0%**
06/13	HCH1 AM	0	50					0	6	
	HCH1 PM	0	50							
	TOTAL	0	100	0.0%	0	0	—	0	6	0.0%
	WCH1 AM				0	1		0	3	
	WCH1 PM							0	1	
	TOTAL	—	—	—	0	1	0.0%	0	4	0.0%
	HST AM	0	50		0	26		0	15	
	HST PM				0	6		0	3	
	TOTAL	0	50	0.0%	0	32	0.0%	0	18	0.0%
	WST AM	0	0		0	1				
	WST PM							0	1	
	TOTAL	0	0	—	0	1	0.0%	0	1	0.0%
	GRAND TOTAL	**0**	**150**	**0.0%**	**0**	**34**	**0.0%**	**0**	**29**	**0.0%**
06/14	HCH1 AM				0	8				
	HCH1 PM									
	TOTAL	0	0	—	0	8	0.0%	0	0	—
	WCH1 AM				0	2				
	WCH1 PM									
	TOTAL	—	—	—	0	2	0.0%	0	0	—
	HST AM				0	6				
	HST PM				0	6				
	TOTAL	0	0	—	0	12	0.0%	0	0	—
	WST AM				0	2				
	WST PM									
	TOTAL	0	0	—	0	2	0.0%	0	0	—
	GRAND TOTAL	**0**	**0**	**—**	**0**	**24**	**0.0%**	**0**	**0**	**—**

* Chinook not differentiated by rearing type at McNary Dam; all chinook tabulated in Hatchery category.

1994 Smolt Monitoring Program Gas Bubble Symptoms from Separator Samples

		McNary Dam*			Little Goose Dam			Lower Monumental Dam		
Date	Species / Sample Time	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS
06/14	HCH1 AM	0	50		0	8		0	9	
	HCH1 PM	0	50					0	4	
	TOTAL	0	100	0.0%	0	8	0.0%	0	13	0.0%
	WCH1 AM				0	2		0	1	
	WCH1 PM									
	TOTAL	—	—	—	0	2	0.0%	0	1	0.0%
	HST AM	0	46		0	6		0	2	
	HST PM	0	46		0	6		0	5	
	TOTAL	0	92	0.0%	0	12	0.0%	0	7	0.0%
	WST AM	0	4		0	2		0	1	
	WST PM	0	4					0	1	
	TOTAL	0	8	0.0%	0	2	0.0%	0	2	0.0%
	GRAND TOTAL	**0**	**200**	**0.0%**	**0**	**24**	**0.0%**	**0**	**23**	**0.0%**
06/15	HCH1 AM	0	50		0	3		0	4	
	HCH1 PM	0	80		0	2		0	1	
	TOTAL	0	130	0.0%	0	5	0.0%	0	5	0.0%
	WCH1 AM				0	5		0	1	
	WCH1 PM							0	2	
	TOTAL	—	—	—	0	5	0.0%	0	3	0.0%
	HST AM	0	48		0	22		0	8	
	HST PM	0	11		0	7		0	10	
	TOTAL	0	59	0.0%	0	29	0.0%	0	18	0.0%
	WST AM	0	2					0	1	
	WST PM	0	1		0	1		0	2	
	TOTAL	0	3	0.0%	0	1	0.0%	0	3	0.0%
	GRAND TOTAL	**0**	**192**	**0.0%**	**0**	**40**	0.0%	**0**	**29**	**0.0%**
06/16	HCH1 AM	0	50					0	2	
	HCH1 PM	0	50		0	1				
	TOTAL	0	100	0.0%	0	1	0.0%	0	2	0.0%
	WCH1 AM							0	1	
	WCH1 PM							0	1	
	TOTAL	—	—	—	0	0	—	0	2	0.0%
	HST AM	0	46		0	48		0	3	
	HST PM	0	49		0	4		0	3	
	TOTAL	0	95	0.0%	0	52	0.0%	0	6	0.0%
	WST AM	0	4		0	2		0	1	
	WST PM	0	1		0	1		0	1	
	TOTAL	0	5	0.0%	0	3	0.0%	0	2	0.0%
	GRAND TOTAL	**0**	**200**	**0.0%**	**0**	**56**	**0.0%**	**0**	**12**	**0.0%**
06/17	HCH1 AM	0	50		0	7		0	32	
	HCH1 PM	0	50		0	2		0	4	
	TOTAL	0	100	0.0%	0	9	0.0%	0	36	0.0%
	WCH1 AM				0	4		0	18	
	WCH1 PM									
	TOTAL	—	—	—	0	4	0.0%	0	18	0.0%
	HST AM	0	25		0	49		0	49	
	HST PM	1	27		0	10		0	20	
	TOTAL	1	52	1.9%	0	59	0.0%	0	69	0.0%
	WST AM	0	2		0	2		0	1	
	WST PM	0	2					0	1	
	TOTAL	0	4	0.0%	0	2	0.0%	0	2	0.0%
	GRAND TOTAL	**1**	**156**	**0.6%**	**0**	**74**	**0.0%**	**0**	**125**	**0.0%**

1994 Smolt Monitoring Program Gas Bubble Symptoms from Separator Samples

Date	Species / Sample Time	McNary Dam* # Obs	McNary Dam* # Samp	McNary Dam* % GBS	Little Goose Dam # Obs	Little Goose Dam # Samp	Little Goose Dam % GBS	Lower Monumental Dam # Obs	Lower Monumental Dam # Samp	Lower Monumental Dam % GBS
6/18	HCH1 AM	0	50		0	11		0	7	
	HCH1 PM	0	50					0	6	
	TOTAL	0	100	0.0%	0	11	0.0%	0	13	0.0%
	WCH1 AM				0	17		0	4	
	WCH1 PM							0	3	
	TOTAL	—	—	—	0	17	0.0%	0	7	0.0%
	HST AM	0	48		0	50		0	43	
	HST PM	0	49		0	9		0	10	
	TOTAL	0	97	0.0%	0	59	0.0%	0	53	0.0%
	WST AM	0	2					0	4	
	WST PM	0	1					0	3	
	TOTAL	0	3	0.0%	0	0	—	0	7	0.0%
	GRAND TOTAL	**0**	**200**	**0.0%**	**0**	**87**	**0.0%**	**0**	**80**	**0.0%**
6/19	HCH1 AM	0	50		0	6		0	6	
	HCH1 PM	0	50					0	2	
	TOTAL	0	100	0.0%	0	6	0.0%	0	8	0.0%
	WCH1 AM				0	14		0	1	
	WCH1 PM							0	4	
	TOTAL	—	—	—	0	14	0.0%	0	5	0.0%
	HST AM	0	48		0	28		0	17	
	HST PM	0	48		0	8		0	10	
	TOTAL	0	96	0.0%	0	36	0.0%	0	27	0.0%
	WST AM	0	2		0	3		0	4	
	WST PM	0	2							
	TOTAL	0	4	0.0%	0	3	0.0%	0	4	0.0%
	GRAND TOTAL	**0**	**200**	**0.0%**	**0**	**59**	**0.0%**	**0**	**44**	**0.0%**
6/20	HCH1 AM	0	50		0	5		0	21	
	HCH1 PM	0	50					0	7	
	TOTAL	0	100	0.0%	0	5	0.0%	0	28	0.0%
	WCH1 AM				0	3		0	5	
	WCH1 PM				0	2		0	3	
	TOTAL	—	—	—	0	5	0.0%	0	8	0.0%
	HST AM	0	48		0	49		0	48	
	HST PM	0	47		0	38		0	22	
	TOTAL	0	95	0.0%	0	87	0.0%	0	70	0.0%
	WST AM	0	2		0	4		0	2	
	WST PM	0	3		0	2		0	5	
	TOTAL	0	5	0.0%	0	6	0.0%	0	7	0.0%
	GRAND TOTAL	**0**	**200**	**0.0%**	**0**	**103**	**0.0%**	**0**	**113**	**0.0%**

* Chinook not differentiated by rearing type at McNary Dam; all chinook tabulated in Hatchery category

1994 Smolt Monitoring Program Gas Bubble Symptoms - Lateral Line and Internal Symptoms
Juvenile 'Hatchery Steelhead

Site	Date	# Sampled	Lateral Line External	Lateral Line Internal	Gill Filaments	Internal Symptoms	Total Affected
Little Goose Dam	5/18	30	0	0	7	1	7
	5/20	30	0	0	8	2	10
	5/22	30	0	0	11	2	12
	5/24	30	0	0	9	0	9
	~~5/26~~	~~15~~	~~0~~	~~0~~	~~5~~	~~2~~	~~6~~
Lower Monumental Dam	5/19	30	0	0	15	6	17
	5/21	30	0	0	7	7	11
	5/23	30	0	0	7	8	14
	5/25	30	0	0	11	7	16
McNary Dam	5/13	30	0	0	1	1	2
	5/15	30	0	0	0	0	0
	5/17	30	0	0	0	0	0
	5/19	30	0	0	0	1	1
	5/21	30	0	0	0	0	0
	5/23	30	0	0	0	0	0
	5/25	30	0	0	0	0	0
John Day Dam	5/17	30	n/a	6	9	0	14
	5/19	30	0	1	10	2	13
	5/21	30	0	2	9	2	13
	5/23	30	2	7	13	7	19
	5/25	30	2	19	13	3	26
Bonneville Dam	5/17	15	0	10	2	1	11
	5/19	30	22	30	13	8	30
	5/21	22	11	19	5	2	19
	5/23	12	5	10	3	4	10
	5/25	30	16	28	21	7	29

1994 Smolt Monitoring/ Program Gas Bubble Symptoms - Lateral Line and Internal Symptoms
Juvenile Hatchery Steelhead

Site	Date	# Sampled	Lateral Line External	Lateral Line Internal	Gill Filaments	Internal Symptoms	Total Affected
Little Goose Dam	5/20	30	0	0	8	2	10
	5/22	30	0	0	11	2	12
	5/24	30	0	0	9	0	9
	5/26	30	0	0	10	3	11
	5/28	30	0	0	6	0	6
	5/30	30	0	0	10	1	10
	6/01	15	0	0	1	1	1
Lower Monumental Dam	5/19	30	0	0	15	6	17
	5/21	30	0	0	7	7	11
	5/23	30	0	0	7	8	14
	5/25	30	0	0	11	7	16
	5/27	30	0	1	6	6	11
	5/29	30	0	0	10	6	11
	5/31	30	0	0	4	6	6
McNary Dam	5/19	30	0	0	0	1	1
	5/21	30	0	0	0	0	0
	5/23	30	0	0	0	0	0
	5/25	30	0	0	0	0	0
	5/27	30	0	0	0	0	0
	5/29	30	0	0	0	1	1
	5/31		0	0	0	0	0
John Day Dam	5/19	30	0	1	10	2	13
	5/21	30	0	2	9	2	13
	5/23	30	2	7	13	7	19
	5/25	30	2	19	13	3	26
	5/27	30	3	17	6	2	19
	5/29	30	0	24	7	0	24
	5/31	30	2	14	14	2	22
Bonneville Dam	5/19	30	22	30	13	8	30
	5/21	22	11	19	5	2	19
	5/23	12	5	10	3	4	10
	5/25	30	16	28	21	7	29
	5/27	30	24	30	21	10	30
	5/29	30	20	29	18	6	29
	5/31		19	30	25	4	30

1994 Smolt Monitoring Program Gas Bubble Symptoms - Lateral Line and Internal Symptoms
Juvenile Hatchery Steelhead

Site	Date	# Sampled	Lateral Line External	Lateral Line Internal	Gill Filaments	Internal Symptoms	Total Affected
Little Goose Dam	6/01	30	0	0	4	1	4
	6/03	30	0	0	5	0	5
	6/05	28	0	0	3	1	4
	6/07	21	0	0	3	0	
	6/09	18	0	0	2	2	4
	6/11	18	0	0	2	1	3
	6/13	1.5	0	0	0	1	1
Lower Monumental Dam	5/29	30	0	0	10	6	11
	5/31	30	0	0	4	6	9
	6/02	30	0	0	4	6	8
	6/04	30	0	0	3	7	9
	6/06	30	0	0	3	6	8
	6/08	13	0	0	4	3	6
	6/10	24	0	0	3	2	5
McNary Dam	6/01	30	0	0	0	0	0
	6/03	30	0	0	0	0	0
	6/05	30	0	0	0	0	0
	6/07	30	0	0	0	0	0
	6/09	15	0	0	0	0	0
	6/11	30	0	0	0	0	0
	6/13	30	0	0	0	0	0
John Day Dam	5/31	30	2	14	14	2	22
	6/02	30	2	4	8	2	14
	6/04	30	1	18	9	3	21
	6/06	30	4	7.4	12	0	27
	6/08	18	0	1	2	1	2
	6/10	30	3	20	5	2	22
	6/12	30	3		7	7	24
Bonneville Dam	5/31	30	19	30	25	4	30
	6/02	30	0	30	9	3	30
	6/04	30	2	26	13	1 1	27
	6/06	30	5	29	9	18	30
	6/08	30	3	26	18	9	29
	6/10	22	2	19	7	0	19
	6/12	30			11	7	28

1994 Smolt Monitoring/ Program Gas Bubble Symptoms- Lateral Line and Internal Symptoms
Juvenile Hatchery Steelhead

Site	Date	# Sampled	Lateral Line External	Lateral Line Internal	Gill Filaments	Internal Symptoms	Total Affected
Little Goose Dam	6/09	18	0	0	2	3	5
	6/11	18	0	0	2	1	3
	6/13	21	0	0	0	1	1
	6/15	22	0	0	0	0	0
	6/17	25	0	0	3	0	3
	6/19	23	0	0	0	0	0
	6/20	8	0	0	0	0	0
Lower Monumental Dam	6/08	13	0	0	4	3	6
	6/10	24	0	0	3	2	5
	6/12	12	0	0	2	3	4
	6/14	7	0	0	1	1	2
	6/16	6	0	0	0	0	0
	6/18	25	0	0	2	2	3
	6/20	30	0	0		3	4
McNary Dam	6/09	15	0	0	0	0	0
	6/11	30	0	0	0	0	0
	6/13	30	0	0	0	0	0
	6/15	30	0	0	0	0	0
	6/17	30	0	0	0	0	0
	6/19	30	0	0	0	0	0
	6/21	30	0	0	0	0	0
John Day Dam	6/08	18	0	1	2	1	2
	6/10	30	3	20	5	2	22
	6/12	30	3	23	7	7	24
	6/14	30	0	15	7	7	20
	6/16	22	0	17	5	2	19
	6/18	20	0	7	0	1	7
	6/20	8	0	6	1	0	6
Bonneville Dam	6/08	30	3	26	18	9	29
	6/10	22	2	19	7	0	19
	6/12	30	1	28	11	7	28
	6/14	30	2	29	6	9	29
	6/16	29	2	29	1	7	29
	6/18	22	0	21	1	1	21
	6/20	5	0	5		0	5

THIS SAMPLING REPRESENTS A MICROSCOPIC EXAMINTION OF 30 SACRIFICED NUMBERS REPORTED REPRESENT. THE PRESENCE OF
ANY POTENTIAL SIGN OF GBT, RANGING FROM THE PRESENCE OF ONE BUBBLE IN A GILL FILAMENT OR LATERAL LINE TO MULTIPLE EFFECTS ON INTERNAL ORGANS. AT THIS TIME ALL CRBWS ARE REPORTING THESE SYMPTOMS AS MINOR INCIDENCE. THE LATERAL LINE IS OBSERVED IN A TWO-STEP PROCESS, INCLUDING AN EXAMINATION OF THE INTACT LATERAL LINB WITH A DISSECTING SCOPE (LL EXT) AND AN EXAMINATION OF THE LATERAL LINE AFTER THE SKIN IS PEELED BACK (INT LL).

1994 NMFS Gas Bubble Symptom Monitoring at FGE sites - Juvenile Salmonids

		Little Goose Dam			McNary Dam			The Dalles Dam			Bonneville Dam		
Date	Species	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS
05/18	HCH1	0	371	0.0%	0	100	0.0%	0	94	0.0%	0	100	0.0%
	WCH1	0	0	—	0	0	—	0	0		0	0	—
	CHO	0	0	—	0	0	—	0	0		0	0	—
	HST	0	166	0.0%	0	137	0.0%	0	46	0.0%	0	100	0.0%
	WST	0	0	—	0	0	—	0	0	—	0	0	
	WSO	0	0	—	0	0	—	0	11	0.0%	0	0	
	COHO	0	0	—	0	0	—	0	53	0.0%	0	100	0.0%
	All Species	0	537	0.0%	0	237	0.0%	0	204	0.0%	0	300	0.0%
05/19	HCH1			—	0	100	0.0%	0	64	0.0%	0	100	0.0%
	WCH1			—	0	0	—	0	0		0	0	-
	CHO			—	0	0	—	0	0		0	0	—
	HST			—	0	83	0.0%	0	43	0.0%	0	100	0.0%
	WST			—	0	0	—	0	0		0	0	—
	WSO			—	0	0	—	0	1 2	0.0%	0	0	—
	COHO			—	0	0	—	0	42	0.0%	0	100	0.0%
	All Species	0	0	-	0	183	10.0%	0	161	0.0%	0	300	0.0%
05/20	HCH1	0	654	0.0%	0	100	0.0%	0	94	0.0%			—
	WCH1	0	0		0	0		0	0				—
	CHO	0	0	—	0	0		0	0				—
	HST	0	340	0.0%	0	52	0.0%	0	92	0.0%			—
	WST	0	0		0	0		0	0				
	WSO	0	0		0	0		0	16	0.0%			
	COHO	0	0		0	0		0	61	0.0%			—
	All Species	0	994	0.0%	0	152	0.0%	0	263	0.0%	0	0	—
05/21	HCH1	0	620	0.0%			—	0	17	0.0%			
	WCH1	0	0	—			—	0	0				
	CHO	0	0	—			—	0	0				—
	HST	0	551	0.0%			—	0	13	0.0%			—
	WST	0	0	—			—	0	0				—
	WSO	0	0	—			—	0	0	—			—
	COHO	0	0	—			—	0	20	3.0%			
	All Species	0	1.171	0.0%	0	0	—	0	50	0.0%	0	0	—
05/22	HCH1	0	527	10.0%	2	98	2.0%						
	WCH1	0		—	0	0	—					0	
	CHO	0	0	—	0	0	—						
	HST	0	536	0.0%	0	32	0.0%						
	WST	0	0	—	0	0	—						—
	WSO	0	0	—	0	0	—						
	COHO	0	0	—	0	0	—						
	All Species	0	1.063	0.0%	2	130	1.5%	0	0	—		0	—
05/23	HCH1	0	241	0.0%	0	100	0.0%	0	52	0.0%			—
	WCH1	0	0	—	0	0	—	0	0				—
	CHO	0	0	—	0	0	—	0	3	—			—
	HST	0	471	0.0%	0	138	0.0%	0	31	1.0%			- -
	WST	0	0	—	0	0	—	0	3	—			—
	WSO	0	0	—	0	0	—	0	1	0.0%			—
	COHO	0	0	—	0	0	—	0	13	0.0%			—
	All Species	0	712	0.0%	0	238	0.0%	0	97	1.0%	0	0	—
05/24	HCH1	0	272	0.0%	0	101	0.0%	0	46	1.0%			
	WCH1	0	0	—	0	0	—	0	3				—
	CHO	0	0	—	0	0	—	0	3				—
	HST	0	467	0.0%	1	84	1.2%	0	70	0.0%			—
	WST	0	0	—	0	0	—	0	3	—			-
	WSO	0	0	—	0	0	—	0	4	3.0%			-
	COHO	0	0	—	0	0	—	0	19	0.0%			—
	All Species	0	739	0.0%	1	185	0.5%	0	139	0.0%	0	0	

1994 NMFS Gas Bubble Symptom Monitoring at FGE sites - Juvenile Salmonids

		Little Goose Dam			McNary Dam			The Dalles Dam			Bonneville Dam		
Date	Species	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS
05/25	HCH1	0	288	0.0%	0	78	0.04	0	100	0.0%			---
	WCH1	0	0	---	0	0	---	0	0				---
	CHO	0	0	---	0	0	---	0	0	---			---
	HST	0	478	0.0%	0	168	0.0%	0	100	0.0%			---
	WST	0	0	---	0	0	---	0	0	---			---
	WSO	0	0	---	0	0	---	0	20	0.0%			---
	COHO	0	0	---	0	0	---	0	60	0.0%			---
	All Species	0	766	0.0%	0	246	0.0%	0	280	0.0%	0	0	---
05/26	HCH1	0	348	0.0%	0	98	0.0%						---
	WCH1	0	0	---	0	0	---						---
	CHO	0	0	---	0	0	---						---
	HST	0	320	0.0%	0	99	0.0%						---
	WST	0	0	---	0	0	---						---
	WSO	0	0	---	0	0	---						---
	COHO	0	0	---	0	0	---						---
	All Species	0	668	0.0%	0	197	0.0%	0	0	---	0	0	---
05/27	HCH1	0	533	0.0%	0	105	0.0%	0	100	0.0%			---
	WCH1	0	0	---	0	0	---	0	0	---			---
	CHO	0	0	---	0	0	---	0	0	---			---
	HST	0	205	0.0%	0	117	0.0%	0	100	0.0%			---
	WST	0	0	---	0	0	---	0	0	---			---
	WSO	0	0	---	0	0	---	0	20	0.0%			---
	COHO	0	0	---	0	0	---	0	40	0.0%			
	All Species	0	738	0.0%	0	222	0.0%	0	260	0.0%	0	0	
05/28	HCH1			---	0	107	0.0%			---			---
	WCH1			---	0	0	---			---			---
	CHO			---	0	0	---			---			---
	HST			---	0	100	0.0%			---			---
	WST			---	0	0	---			---			---
	WSO			---	0	0	---			---			---
	COHO			---	0	0	---			---			---
	All Species	0	0	---	0	207	0.0%	0	0	---	0		---
05/29	HCH1			---	0	101	0.0%			---			---
	WCH1			---	0	0	---			---			---
	CHO			---	0	0	---			---			---
	HST			---	0	138	0.0%			---			---
	WST			---	0	0	---			---			---
	WSO			---	0	0	---			---			---
	COHO			---	0	0	---			---			---
	All Species	0	0	---	0	239	0.0%	0	0	---	0	0	---
05/30	HCH1			---	0	119	0.0%			---			---
	WCH1			---	0	0	---			---			---
	CHO			---	0	0	---			- -			---
	HST			---	0	125	0.0%			- -			---
	WST			---	0	0	---			---			---
	WSO			---	0	0	---			---			---
	COHO			---	0	0	---			- -			---
	All Species	0	0	---	0	244	0.0%	0	0	---	0	0	---
05/31	HCH1			---	0	100	0.0%			- -			---
	WCH1			---	0	0	---			---			---
	CHO			---	0	0	---			---			---
	HST			---	2	99	2.0%			---			---
	WST			---	0	0	---			---			---
	WSO			---	0	0	---			---			---
	COHO			---	0	0	---			---			---
	All Species	0	0	---	2	199	1.0%	0	0		0	0	---

1994 NMFS Gas Bubble Symptom Monitoring FGE sites - Juvenile Salmonids

		Little Goose Dam			McNary Dam			The Dalles Dam			Bonneville Dam		
Date	Species	# Obs	# Samp	%GBS	# Obs	# Samp	% GBS	#Obs	# Samp	% GBS	# Obs	# Samp	% CBS
05/27	HCH1	0	533	0.0%	0	105	0.0%	0	100				
	WCH1			—			—			0.0%			
	CHO			—									
	HST	0	205	0.0%	0	117	0.0%	0	100	0.0%			
	WST			—			—						
	WSO			—			—	0	20	0.0%			
	COHO			—			—	0	40	0.0%			
	All Species	**0**	738	**0.0%**	**0**	222	**0.0%**	**0**	**260**	**0.0%**	**0**	**0**	—
05/28	HCH1			—	0	107	0.0%						
	WCH1			—									
	CHO			—									
	HST			—	0	100	0.0%						
	WST			—									
	WSO			—									
	COHO			—									
	All Species	0	**0**	—	**0**	207	**0.0%**	**0**	**0**	—	**0**	**0**	—
05/29	HCH1			—	0	101	0.0%						
	WCH1			—									
	CHO			—									
	HST			-	0	138	0.0%						
	WST			—			—						
	WSO			—									
	COHO			—			—						
	All Species	0	**0**	—	0	239	**0.0%**	0	a	—	**0**	**0**	—
05/30	HCH1			—	0	119	0.0%						
	WCH1			—									
	CHO			—									
	HST			—	0	125	0.0%						
	WST			-			—						
	WSO			—									
	COHO			—									
	All Species	**0**	**0**	—	0	244	**0.0%**	0	0	—	**0**	**0**	—
05/31	HCH1			—	0	100	0.0%						
	WCH1			—			—						
	CHO			—			—						
	HST			—	2	99	2.0%						
	WST			—			—						
	WSO			—									
	COHO			—			—						
	All Species	**0**	**0**	—	2	199	1.0%	0	0	—	**0**	**0**	—
06/01	HCH1			—	0	103	0.0%						
	WCH1			—			—						
	CHO			—			—						
	HST			—	0	100	0.0%						
	WST			—			—						
	WSO			—			—						
	COHO			—									
	All Species	0	**0**	—	**0**	203	**0.0%**	0	**0**	—	**0**	**0**	—
06/02	HCH1				0	102	0.0%						
	WCH1			—			—						
	CHO			—			—						
	HST			—	00	100	0.0%						
	WST			—			—						
	WSO			—			—						
	COHO			—			—						
	All Species	0	**0**	—	00	202	**0.0%**	**0**	**0**		**0**	**0**	—

NMFS Gas Bubble Symptom River Reach Monitoring - Juvenile Salmonids

Date	Species	Below Bonneville Dam # Obs	# Samp	% GBS	Below Ice Harbor Dam # Obs	# Samp	% GBS	Below Priest Rapids Dam # Obs	# Samp	% GBS
05/18	CH1			—	0	2	0.0%			—
	WCH1			—	0	0	—			—
	CHO			—	0	0	—			—
	HST			—	0	0	—			—
	WST			—	0	0	—			—
	WSO			—	0	0	—			—
	COHO			—	0	0	—			—
	All Salmonids	**0**	**0**	—	**0**	**2**	**0.0%**	**0**	**0**	—
	Nonsalmonids			—	7	170	4.1%			—
05/19	CH1			—			—	0	3	0.0%
	WCH1			—			—	0	0	—
	CHO			—			—	0	4	0.0%
	HST			—			—	0	0	—
	WST			—			—	0	0	—
	WSO			—			—	0	0	—
	COHO			—			—	0	3	0.0%
	All Salmonids	**0**	**0**	—	**0**	**0**	—	**0**	**10**	**0.0%**
	Nonsalmonids			—			—	0	105	0.0%
5/20	CH1			—			—	0	16	0.0%
	WCH1			—			—	0	0	—
	CHO			—			—	0	103	0.0%
	HST			—			—	0	1	0.0%
	WST			—			—	0	0	—
	WSO			—			—	0	0	—
	COHO			—			—	0	8	0.0%
	All Salmonids	**0**	**0**	—	**0**	**0**	—	**0**	**128**	**0.0%**
	Nonsalmonids			—			—	0	63	0.0%
5/21	CH1			—			—			—
	WCH1			—			—			—
	CHO			—			—			—
	HST			—			—			—
	WST			—			—			—
	WSO			—			—			—
	COHO									
	All Salmonids	**0**	**0**	—	**0**	**0**	—	**0**	**0**	—
	Nonsalmonids			—			—			—
5/22	CH1			—			—			—
	WCH1			—			—			—
	CHO			—			—			—
	HST			—			—			—
	WST			—			—			—
	WSO			—			—			—
	COHO			—			—			—
	All Salmonids	**0**	**0**	—	**0**	**0**	—	**0**	**0**	—
	Nonsalmonids			—			—			
5/23	CH1	0	5	0.0%	0	0	—			—
	WCH1	0	0	—	0	0	—			—
	CHO	0	95	0.0%	0	0	—			—
	HST	0	0	—	0	0	—			—
	WST	0	0	—	0	0	—			
	WSO	0	0	—	0	0	—			—
	COHO	0	0	—	0	0	—			—
	All Salmonids	**0**	**100**	**0.0%**	**0**	**0**	—	**0**	0	—
	Nonsalmonids	0	168	0.0%	2	151	1.3%			
5/24	CH1	0	19	0.0%	0	0	—	0	5	0.0%
	WCH1	0	0	—	0	0	—	0	0	—
	CHO	0	57	0.0%	0	0	—	0	93	0.0%
	HST	0	0	—	0	0	—	0	0	—
	WST	0	0	—	0	0	—	0	0	—
	WSO	0	0	—	0	0	—	0	0	—
	COHO	0	1	0.0%	0	0	—	0	3	0.0%
	All Salmonids	**0**	**77**	**0.0%**	**0**	**0**	—	**0**	**101**	**0.0%**
	Nonsalmonids	0	62	0.0%	3	78	3.8%	0	4	0.0%

1994 NMFS Gas Bubble Symptom River Reach Monitoring - Juvenile Salmonids

		Below Bonneville Dam			Below Ice Harbor Dam			Below Priest Rapids Dam		
Date	Species	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS
05/20	CH1			—			—	0	16	0.0%
	WCH1			—			—	0	0	—
	CHO			—			—	0	103	0.0%
	HST			—			—	0	1	0.0%
	WST			—			—	0	0	—
	WSO			—			—	0	0	—
	COHO			—			—	0	8	0.0%
	All Salmonids	**0**	**0**	—	**0**	**0**	—	**0**	**128**	**0.0%**
	Nonsalmonids			—			—	0	63	0.0%
05/21	CH1			—			—			—
	WCH1			—			—			—
	CHO			—			—			—
	HST			—			—			—
	WST			—			—			—
	WSO			—			—			—
	COHO			—			—			—
	All Salmonids	**0**	**0**	—	**0**	**0**	—	**0**	**0**	—
	Nonsalmonids			—			—			—
05/22	CH1			—			—			—
	WCH1			—			—			—
	CHO			—			—			—
	HST			—			—			—
	WST			—			—			—
	WSO			—			—			—
	COHO			—			—			—
	All Salmonids	**0**	**0**	—	**0**	**0**	—	**0**	**0**	—
	Nonsalmonids			—			-			-
05/23	CH1	0	5	10.0%	0	0	—			
	WCH1	0	0	—	0	0	—			
	CHO	0	95	0.0%	0	0	—			
	HST	0	0	—	0	0	—			
	WST	0	0	—	0	0	—			
	WSO			—	0	0	—			—
	COHO	0	0	—	0	0	—			—
	All Salmonids	**0**	**100**	**0.0%**	**0**	**0**	—			—
	Nonsalmonids	0	168	0.0%	2	151	1.3%	0	0	—
05/24	CH1	0	19	0.0%	0	0	—	0	5	0.0%
	WCH1	0	0	—	0	0	—	0	0	—
	CHO	0	57	0.0%	0	0	—	0	93	0.0%
	HST	0	0	—	0	0	—	0	0	—
	WST	0	0	—	0	0	—	0	0	—
	WSO	0	0	—	0	0	—	0	0	—
	COHO	0	1	0.0%	0	0	—	0	3	0.0%
	All Salmonids	**0**	**77**	**0.0%**	**0**	**0**	—	**0**	**101**	**0.0%**
	Nonsalmonids	0	62	0.0%	3	78	3.8%	0	4	0.0%
05/25	CH1	0	5	0.0%	0	0	—			—
	WCH1	0	0	—	0	0	—			—
	CHO	0	20	0.0%	0	0	—			—
	HST	0	0	—	0	5	0.0%			—
	WST	0	0	—	0	0	—			—
	WSO	0	0	—	0	0	—			—
	COHO	0	0	—	0	2	0.0%			—
	All Salmonids	**0**	**25**	**0.0%**	**0**	**7**	**0.0%**	**0**	**0**	—
	Nonsalmonids	0	10	0.0%	2	212	(0.9%			—
05/26	CH1			—			—	0	10	0.0%
	WCH1			—			—	0	0	—
	CHO			—			—	0	87	0.0%
	HST			—			—	0	0	—
	WST			—			—	0	0	—
	WSO			—			—	0	0	—
	COHO			—			—	0	4	0.0%
	All Salmonids	**0**	**0**	—	**0**	**0**	—	**0**	**101**	**0.0%**
	Nonsalmonids			—			—	2	160	1.3%

		Below Bonneville Dam			Below Ice Harbor Dam			Below Priest Rapids Dam		
Date	Species	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS
05/26	CH1			---			---	0	10	0.0%
	WCH1			---			---			---
	CHO			---			---	0	87	0.0%
	HST			---			---			---
	WST			---			---			---
	WSO			---			---			---
	COHO			---			---	0	4	0.0%
	All Salmonids	**0**	**0**	---	**0**	**0**	---	**0**	**101**	**0.0%**
	Nonsalmonids			---			---	2	160	1.3%
05/27	CH1			---			---			---
	WCH1			---			---			---
	CHO			---			---			---
	HST			---	0	1	0.0%			---
	WST			---			---			---
	WSO			---			---			---
	COHO			---			---			---
	All Salmonids	**0**	**0**	---	**0**	**1**	**0.0%**	**0**	**0**	---
	Nonsalmonids			---	6	108	5.6%			---
05/28	CH1			---			---			---
	WCH1			---			---			---
	CHO			---			---			---
	HST			---			---			---
	WST			---			---			---
	WSO			---			---			---
	COHO			---			---			---
	All Salmonids	**0**	**0**	---	**0**	**0**	---	**0**	**0**	---
	Nonsalmonids			---			---			---
05/29	CH1			---			---			---
	WCH1			---			---			---
	CHO			---			---			---
	HST			---			---			---
	WST			---			---			---
	WSO			---			---			---
	COHO			---			---			---
	All Salmonids	**0**	0	---	0	**0**	---	0	0	---
	Nonsalmonids			---			---			---
05/30	CH1	0	13	0.0%			---			---
	WCH1			---			---			---
	CHO	0	84	0.0%			---			---
	HST			---	0	1	0.0%			---
	WST			---			---			---
	WSO			---			---			---
	COHO			---			---			---
	All Salmonids	**0**	97	**0.0%**	**0**	**1**	**0.0%**	0	0	---
	Nonsalmonids	0	103	0.0%	9	179	5.0%			---
05/31	CH1	0	49	0.0%			---	0	6	0.0%
	WCH1			---			---			---
	CHO	0	41	0.0%			---	0	94	0.0%
	HST			---			---			---
	WST			---			---			---
	WSO			---			---			---
	COHO	0	4	0.0%			---			---
	All Salmonids	**0**	**94**	**0.0%**	**0**	**0**	---	**0**	**100**	**0.0%**
	Nonsalmonids	0	67	0.0%			---	3	234	1.3%
06/01	CH1			---			---			---
	WCH1			---			---			---
	CHO			---			---			---
	HST			---			---			---
	WST			---			---			---
	WSO			---			---			---
	COHO			---			---			---
	All Salmonids			---	**0**	**0**	---			---
	Nonsalmonids			---			---	0	102	0.0%

1994 NMFS Gas Bubble Symptom River Reach Monitoring -Juvenile Salmonids

		Below Bonneville Dam			Below Ice Harbor Dam			Below Priest Rapids Dam		
Date	Species	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS
05/31	CH1	0	49	0.0%			---	0	6	0.0%
	WCH1			---			---			---
	CHO	0	41	0.0%			---	0	94	0.0%
	HST			---			---			---
	WST			---			---			---
	WSO			---			---			---
	COHO	0	4	0.0%			---			---
	All Salmonids	**0**	**94**	**0.0%**	**0**	**0**	**---**	**0**	**100**	**0.0%**
	Nonsalmonids	0	67	0.0%			---	3	234	1.3%
06/01	CH1			---			---			---
	WCH1			---			---			---
	CHO			---			---			---
	HST			---			---			---
	WST			---			---			---
	WSO			---			---			---
	COHO			---			---			---
	All Salmonids	**0**	**0**	**---**	**0**	**0**	**---**	**0**	**0**	**---**
	Nonsalmonids			---			---	0	102	0.0%
06/02	CH1			---			---			---
	WCH1			---			---			---
	CHO			---			---			---
	HST			---			---			---
	WST			---			---			---
	WSO			---			---			---
	COHO			---			---			---
	All Salmonids	**0**	**0**	**---**	**0**	**0**	**---**	**0**	**0**	**---**
	Nonsalmonids			---			---			---
06/03	CH1			---			---			---
	WCH1			---			---			---
	CHO			---			---			---
	HST			---	0	1	0.0%			---
	WST			---			---			---
	WSO			---			---			---
	COHO			---	0	1	0.0%			---
	All Salmonids	**0**	**0**	**---**	**0**	**2**	**0.0%**	**0**	**0**	**---**
	Nonsalmonids			---	0	102	0.0%			---
06/04	CH1			---			---	0	21	0.0%
	WCH1			---			---			---
	CHO			---			---	0	31	0.0%
	HST			---			---			---
	WST			---			---			---
	WSO			---			---			---
	COHO			---			---			---
	All Salmonids	**0**	**0**	**---**	**0**	**0**	**---**	**0**	**52**	**0.0%**
	Nonsalmonids			---			---			---
06/05	CH1			---			---			---
	WCH1			---			---			---
	CHO			---			---			---
	HST			---			---			---
	WST			---			---			---
	WSO			---			---			---
	COHO			---			---			---
	All Salmonids	**0**	**0**	**---**	**0**	**0**	**---**	**0**	**0**	**---**
	Nonsalmonids			---			---			---
06/06	CH1	0	8	0.0%			---			---
	WCH1			---			---			---
	CHO	0	20	0.0%			---			---
	HST			---			---			---
	WST			---			---			---
	WSO			---			---			---
	COHO	0	1	0.0%			---			---
	All Salmonids	**0**	**29**	**0.0%**	**0**	**0**	**---**	**0**	**0**	**---**
	Nonsalmonids	0	181	0.0%	1	291	0.3%			---

1994 NMFS Gas Bubble Symptom River Reach **Monitoring** -Juvenile **Salmonids**

		Below Bonneville Dam			Below Ice Harbor Dam			Below Priest Rapids Dam		
Date	Species	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS
06/03	CH1			---			---			---
	WCH1			---			---			---
	CHO			---			---			---
	HST			---	0	1	0.0%			---
	WST			---			---			---
	WSO			---			---			---
	COHO			---	0	1	0.0%			---
	All Salmonids	**0**	**0**	**---**	**0**	**2**	**0.0%**	**0**	**0**	**---**
	Nonsalmonids			---	0	102	0.0%			---
06/04	CH1			---			---	0	21	0.0%
	WCH1			---			---			---
	CHO							0	31	0.0%
	HST									--
	WST			---			---			---
	WSO			---			---			---
	COHO			---			---			---
	All Salmonids	**0**	**0**	**---**	**0**	**0**	**---**	**0**	**52**	**0.0**
	Nonsalmonids			---			---			---
06/05	CH1			---			---			---
	WCH1			---			---			---
	CHO			---			---			---
	HST			---			---			---
	WST			---			---			---
	WSO			---			---			---
	COHO			---			---			---
	All Salmonids	0	0	---	0	0	---	0	0	---
	Nonsalmonids			---			---			---
06/06	CH1	0	8	0.0%			---			---
	WCH1			---			---			---
	CHO	0	20	0.0%			---			---
	HST			---			---			---
	WST			---			---			---
	WSO			---			---			---
	COHO	0	1	0.0%			---			---
	All Salmonids	**0**	**29**	**0.0%**	**0**	**0**	**---**	**0**	**0**	**---**
	Nonsalmonids	0	181	0.0%	1	291	0.3%			---
06/07	CH1	0	42	0.0%			---	0	70	0.0%
	WCH1			---			---			---
	CHO	0	4	0.0%			---	0	30	0.0%
	HST	0	2	0.0%			---			---
	WST			---			---			---
	WSO			---			---			---
	COHO	0	5	0.0%			---			---
	All Salmonids	**0**	**53**	**0.0%**	**0**	**0**	**---**	**0**	**100**	**0.0%**
	Nonsalmonids	0	77	0.0%			---	0	126	0.0%
06/08	CH1			---				0	63	0.0%
	WCH1			---			---			
	CHO			---		---		0	37	0.0%
	HST			---		---				---
	WST			---			---			---
	WSO			---			---			---
	COHO			---			---			---
	All Salmonids	**0**	**0**	**---**	**0**	**0**	**---**	**0**	**100**	**0.0%**
	Nonsalmonids			---			---	0	123	0.0%
06/09	CH1			---			---			---
	WCH1			---			---			---
	CHO			---			---			---
	HST			---			---			---
	WST			---			---			---
	WSO			---			---			---
	COHO			---			---			---
	All Salmonids	0	0	---	0	0	---	0	0	---
	Nonsalmonids			---	0	639	0.0%			---

1994 NMFS Gas Bubble Symptom River Reach Monitoring - Juvenile Salmonids

		Below Bonneville Dam			Below Ice Harbor Dam			Below Priest Rapids Dam		
Date	Species	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS	# Obs	#Samp	% GBS
06/10	CH!			—			—			—
	WCH 1			—			—			—
	CHO			—			—			—
	HST			—			—			—
	WST			—			—			—
	WSO			—			—			—
	COHO			—			—			—
	All Salmonids	0	0	—	0	0	—	0	0	—
	Nonsamonids			—	0	116	0.0%			—
06/11	CH1			—			—			—
	WCH1			—			—			—
	CHO			—			—			—
	HST			—			—			—
	WST			—			—			—
	WSO			—			—			—
	COHO			—			—			—
	Au Salmonids	0	0	—	0	0	—	0	0	—
	Nonsalmonids			—			—			—
06/12	CH1			-			—			—
	WCH1			.			—			—
	CHO			-			—			—
	HST			-			—			—
	WST			.			—			—
	WSO			—			—			—
	COHO			.			—			—
	All Salmonids	0	0	.	0	0	—	0	0	—
	Nonsalmonids			—			—			—
06/13	CH1	0	42	0.0%			—			—
	WCH1			.			—			—
	CHO	0	14	0.0%			—			—
	HST			—			—			—
	WST			.			—			—
	WSO			.			—			—
	COHO			—			—			—
	All Salmonids	0	56	0.0%	0	0	—	0	0	—
	Nonsalmonids	0	110	0.0%	8	314	2.1%	0	239	0.0%
06/14	CH1	0	4	0.0%			—			—
	WCH1			.			—			—
	CHO	0	11	0.0%			—			—
	HST			.			—			—
	WST			.			—			—
	WSO			.			—			—
	COHO			.			—			—
	All Salmonids	0	15	0.0%	0	0	—	0	0	—
	Nonsalmonids	0	141	0.0%	0	183	0.0%			—
06/15	CH1			.						—
	WCH1			.						—
	CHO			.						—
	HST			.						—
	WST			—			—			—
	WSO			.						—
	COHO			.						—
	All Salmonids	0	0	.	0	0		0	0	—
	Nonsalmonids			—	4	224	1.8%			—
06/16	CHl			.			—			—
	WCH1			—						—
	CHO			—			—			—
	HST			.						—
	WST			—			—			—
	WSO			.						—
	COHO			.						—
	All Salmonids	0	0	.	0	0		0	0	—
	Nonsalmonids			.	1	204	0.5%			—

1994 NMFS Gas Bubble Symptom River Reach Monitoring - Juvenile Salmonids

		Below Bonneville Dam			Below Ice Harbor Dam			Below Priest Rapids Dam		
Date	Species	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS
06/14	CH1	0	4	0.0%			—			—
	WCH1			—			—			—
	CHO	0	11	0.0%			—			—
	HST			—			—			—
	WST			—			—			—
	WSO			—			—			—
	COHO			—			—			—
	All Salmonids	**0**	**15**	**0.0%**	**0**	**0**	**—**	**0**	**0**	**—**
	Nonsalmonids	0	141	0.0%	0	183	0.0%			—
06/15	CH1			—			—			—
	WCH1			—			—			—
	CHO			—			—			—
	HST			—			—			—
	WST			—			—			—
	WSO			—			—			—
	COHO			—			—			—
	All Salmonids	**0**	**0**	**—**	**0**	**0**	**—**	**0**	**0**	**—**
	Nonsalmonids			—	4	224	1.8%			—
06/16	CH1			—			—			—
	WCH1			—			—			—
	CHO			—			—			—
	HST			—			—			—
	WST			—			—			—
	WSO			—			—			—
	COHO			—			—			—
	All Salmonids	**0**	**0**	**—**	**0**	**0**	**—**	**0**	**0**	**—**
	Nonsalmonids			—	1	204	0.5%			—
06/17	CH1			—			—			—
	WCH1			—			—			—
	CHO			—			—			—
	HST			—			—			—
	WST			—			—			—
	WSO			—			—			—
	COHO			—			—			—
	All Salmonids	**0**	**0**	**—**	**0**	**0**	**—**	**0**	**0**	**—**
	Nonsalmonids			—			—			—
06/18	CH1			—			—			—
	WCH1			—			—			—
	CHO			—			—			—
	HST			—			—			—
	WST			—			—			—
	WSO			—			—			—
	COHO			—			—			—
	All Salmonids	**0**	**0**	**—**	**0**	**0**	**—**	**0**	**0**	**—**
	Nonsalmonids			—			—			—
06/19	CH1			—			—			—
	WCH1			—			—			—
	CHO			—			—			—
	HST			—			—			—
	WST			—			—			—
	WSO			—			—			—
	COHO			—			—			—
	All Salmonids	**0**	**0**	**—**	**0**	**0**	**—**	**0**	**0**	**—**
	Nonsalmonids			—			—			—
06/20	CH1	0	58	0.0%			—			—
	WCH1			—			—			—
	CHO	0	1	0.0%			—			—
	HST			—			—			—
	WST			—			—			—
	WSO			—			—			—
	COHO			—			—			—
	All Salmonids	**0**	**59**	**0.0%**	**0**	**0**	**—**	**0**	**0**	**—**
	Nonsalmonids	0	159	0.0%	0	234	0.0%			—

1994 NMFS Gas Bubble Symptom Net Pen Studies - Hatchery Sub

Date		Below Bonneville Dam					Below Ice Harbor Dam					Below priest Rapids Dam				
		% TDG	# Obs	# Samp	% GBS	Morts	% TDG	# Obs	# Samp	% GBS	Morts	% TDG	# Obs	# Samp	% GBS	Morts
5/9-13	TDG	117					122									
	Test		1	38	2.6%	0		17	56	30.4%	4				—	
	Control		0	20	0.0%	0		2	10	20.0%	1				—	
5/16-20	TDG	115					118									
	Test		0	30	0.0%	0		1	28	3.6%	2				—	
	Control		0	20	0.0%	0		0	12	0.0%	0				—	
5/23-27	TDG	116					118									
	Test		1	39	2.6%	0		3	8	37.5%	1				—	
	Control		1	18	5.6%	0		0	15	0.0%	0				—	
5/30-6/3	TDG						118									
	Test		0	48	0.0%	0		3	54	5.6%	0				—	
	Control		3	25	12.0%	0		0	20	0.0%	0				—	
6/06-6/1	TDG						118									
	Test		0	57	0.0%	0		0	47	0.0%	0				—	
	Control		0	19	0.0%	0		0	25	0.0%	0				—	

1994 NMFS Gas Bubble Symptom Monitoring at Traps - Adult Salmonids

		Bonneville Dam			Ice Harbor Dam			Lower Granite Dam		
Date	Species	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS
05/18	Chinook			—			—	0	16	0.0%
	Sockeye									
	Steelhead			—			—			—
	All Species	0	0	—	0	0	—	0	16	0.0%
05/19	Chinook			—			—	0	13	0.0%
	Sockeye			—			—			—
	Steelhead			—			—			—
	All Species	0	0	—	0	0	—	0	13	0.0%
05/20	Chinook	0	4	0.0%	0	6	10.0%	0	9	10.0%
	Sockeye									—
	Steelhead	0	9	0.0%			—			—
	All Species	0	13	0.0%	0	6	0.0%	0	9	0.0%
05/21	Chinook			—			—	0	7	0.0%
	Sockeye			—			—			—
	Steelhead			—			—			—
	All Species	0	0	—	0	0	—	0	7	0.0%
05/22	Chinook							0	8	10.0%
	Sockeye			—			—			—
	Steelhead			—			—			—
	All Species	0	0	—	0	0	—	0	8	0.0%
05/23	Chinook	0	13	0.0%	0	7	0.0%			—
	Sockeye	0	0	—	0	0	—			—
	Steelhead	0	9	0.0%	0	0	—			—
	All Species	0	22	0.0%	0	7	0.0%	0	0	—
05/24	Chinook			—	0	6	0.0%	0	7	0.0%
	Sockeye			—	0	0	—	0	0	—
	Steelhead			—	0	0	—	0	0	—
	All Species	0	0	—	0	6	0.0%	0	7	0.0%

1994 NMFS Gas Bubble Symptom Monitoring at Traps - Adult Salmonids

		Bonneville Dam			Ice Harbor Dam			Lower Granite Dam		
Date	Species	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS
05/25	Chinook	0	16	0.0%	0	6	0.0%	0	11	0.0%
	Sockeye			---			---			---
	Steelhead	0	6	0.0%			---			---
	All Species	0	22	0.0%	0	6	0.0%	0	11	0.0%
05/26	Chinook			---	0	4	0.0%	0	14	0.0%
	Sockeye			---			---			---
	Steelhead			---			---			---
	All Species	0	0	---	0	4	0.0%	0	14	0.0%
05/27	Chinook				0	2	0.0%	0	4	0.0%
	Sockeye			---			---			---
	Steelhead			---			---			---
	All Species	0	0	---	0	2	0.0%	0	4	0.0%
05/28	Chinook			---			---	0	11	0.0%
	Sockeye			---			---			---
	Steelhead			---			---			---
	All Species	0	0	---	0	0	---	0	11	0.0%
05/29	Chinook			---			---	0	12	0.0%
	Sockeye			---			---			---
	Steelhead			---			---			---
	All Species	0	0	---	0	0	---	0	12	0.0%
05/30	Chinook				0	6	0.0%	0	2	0.0%
	Sockeye			---			---			---
	Steelhead			---			---			---
	All Species	0	0	---	0	6	0.0%	0	2	0.0%
05/31	Chinook	0	21	0.0%	0	5	0.0%	0	8	0.0%
	Sockeye			---			---			---
	Steelhead	0	10	0.0%			---			---
	All Species	0	31	0.0%	0	5	0.0%	0	8	0.0%

1994 NMFS Gas Bubble Symptom Monitoring at Traps - Adult Salmonids

		Bonneville Dam			Ice Harbor Dam			Lower Granite Dam		
Date	Species	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS
05/30	Chinook			---	0	6	0.0%	0	2	0.0%
	Sockeye			---			---			---
	Steelhead			---			---			---
	All Species	0	0	---	0	6	0.0%	0	2	0.0%
05/31	Chinook	0	21	0.0%	0	5	0.0%	0	8	0.0%
	Sockeye			---			---			---
	Steelhead	0	10	0.0%			---			---
	All Species	0	31	0.0%	0	5	0.0%	0	8	0.0%
06/01	Chinook	0	29	0.0%	0	5	0.0%	0	6	0.0%
	Sockeye			---			---			---
	Steelhead	0	15	0.0%			---			---
	All Species	0	44	0.0%	0	5	0.0%	0	6	0.0%
06/02	Chinook			---	0	6	0.0%	0	2	0.0%
	Sockeye			---			---			---
	Steelhead			---			---			---
	All Species	0	0	---	0	6	0.0%	0	2	0.0%
06/03	Chinook	0	10	0.0%	0	5	0.0%	0	10	0.0%
	Sockeye			---			---			---
	Steelhead	0	5	0.0%			---			---
	All Species	0	15	0.0%	0	5	0.0%	0	10	0.0%
06/04	Chinook			---			---	0	7	0.0%
	Sockeye			---			---			---
	Steelhead			---			---			---
	All Species	0	0	---	0	0	---	0	7	0.0%
06/05	Chinook			---			---	0	6	0.0%
	Sockeye			---			---			---
	Steelhead			---			---			---
	All Species	0	0	---	0	0	---	0	6	0.0%

1994 NMFS Gas Bubble Symptom Monitoring at Traps - Adult Salmonids

		Bonneville Dam			ICC Harbor Dam			Lower Granite Dam		
Date	Species	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS
06/03	Chinook	0	10	0.0%	0	5	0.0%	0	10	0.0%
	Sockeye			---			---			---
	Steelhead	0	5	0.0%			---			---
	All Species	0	15	0.0%	0	5	0.0%	0	10	0.0%
06/04	Chinook			---			---	0	7	0.0%
	Sockeye			---			---			---
	Steelhead			---			---			---
	All Species	0	0	---	0	0	---	0	7	0.0%
06/05	Chinook							0	6	0.0%
	Sockeye						---			---
	Steelhead			---			---			---
	All Species	0	0	---	0	0	---	0	6	0.0%
06/06	Chinook			---	0	3	0.0%	0	3	0.0%
	Sockeye			---			---			---
	Steelhead			---			---			---
	All Species	0	0	---	0	3	0.0%	0	3	0.0%
06/07	Chinook			---	0	3	0.0%	0	7	0.0%
	Sockeye			---			---			---
	Steelhead			---			---			---
	All Species	0	0	---	0	3	0.0%	0	7	0.0%
06/08	Chinook	0	25	0.0%	0	4	0.0%	0	10	0.0%
	Sockeye	0	2	0.0%			---			---
	Steelhead	0	15	0.0%			---			---
	All Species	0	42	0.0%	0	4	0.0%	0	10	0.0%
06/09	Chinook			---	0	3	0.0%	0	11	0.0%
	Sockeye			---			---			---
	Steelhead			---			---			---
	All Species	0	0	---	0	3	0.0%	0	11	0.0%

1994 NMFS Gas Bubble Symptom Monitoring at Traps - Adult Salmonids

		Bonneville Dam			Ice Harbor Dam			Lower Granite Dam		
Date	Species	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS
06/10	Chinook			—	0	3	0.0%	0	8	0.0%
	Sockeye			—			—			—
	Steelhead			—			—			—
	All Species	**0**	**0**	—	**0**	**3**	**0.0%**	**0**	**8**	0.0%
06/11	Chinook			—			—	0	8	0.0%
	Sockeye			—			—			—
	Steelhead			—			—			—
	All Species	**0**	**0**	—	**0**	**0**	—	**0**	**8**	0.0%
06/12	Chinook			—			—	0	10	0.0%
	Sockeye			—			—			—
	Steelhead			—			—			
	All Species	**0**	**0**	—	**0**	**0**	—	**0**	**10**	0.0%
06/13	Chinook			—	0	5	0.0%	0	11	0.0%
	Sockeye			—			—			—
	Steelhead			—			—			—
	All Species	**0**	**0**	—	**0**	**5**	**0.0%**	**0**	**11**	0.0%
06/14	Chinook			—	0	4	0.0%	0	6	0.0%
	Sockeye			—			—			—
	Steelhead			—			—			—
	All Species	**0**	**0**	—	**0**	**4**	**0.0%**	**0**	**6**	0.0%
06/15	Chinook	0	34	0.0%			—	0	7	0.0%
	Sockeye	0	23	0.0%			—			—
	Steelhead	0	29	0.0%			—			
	All Species	**0**	**86**	**0.0%**	**0**	**0**	—	**0**	**7**	0.0%
06/16	Chinook			—	0	5	0.0%	0	18	0.0%
	Sockeye			—			—			—
	Steelhead			—			—			—
	All Species		0	0 —	**0**	**5**	**0.0%**	**0**	**18**	0.0%

1994 NMFS Gas Bubble Symptom Monitoring at Traps - Adult Salmonids

		Bonneville Dam			Ice Harbor Dam			Lower Granite Dam		
Date	Species	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS	# Obs	# Samp	% GBS
06/15	Chinook	0	34	0.0%			—	0	7	0.0%
	Sockeye	0	23	0.0%			—			—
	Steelhead	0	29	0.0%			—			—
	All Species	**0**	**86**	**0.0%**	**0**	**0**	**—**	**0**	**7**	**0.0%**
06/16	Chinook	0	35	0.0%	0	5	0.0%	0	18	0.0%
	Sockeye	0	38	0.0%			—			—
	Steelhead	0	31	0.0%			—			—
	All Species	**0**	**104**	**0.0%**	**0**	**5**	**0.0%**	**0**	**18**	**0.0%**
06/17	Chinook			—			—	0	4	0.0%
	Sockeye			—			—			—
	Steelhead			—			—			—
	All Species	**0**	**0**	**—**	**0**	**0**		**0**	4	0.0%
06/18	Chinook						—	0	5	0.0%
	Sockeye									—
	Steelhead			—			—			—
	All Species	**0**	**0**	**—**	**0**	**0**	**—**	**0**	**5**	**0.0%**
06/19	Chinook			—			—	0	9	0.0%
	Sockeye			—			—			—
	Steelhead			—			—			—
	All Species	**0**	**0**	**—**	**0**	**0**	**—**	**0**	**9**	**0.0%**
06/20	Chinook	0	26	0.0%	0	3	0.0%	0	3	0.0%
	Sockeye	0	27	0.0%			—			—
	Steelhead	0	13	0.0%			—			—
	All Species	**0**	**66**	**0.0%**	**0**	**3**	**0.0%**	**0**	**3**	**0.0%**
06/21	Chinook			—			—	0	9	0.0%
	Sockeye			—			—			—
	Steelhead			—			—			—
	All Species	**0**	**0**	**—**	**0**	**0**	**—**	**0**	**9**	**0.0%**

Daily Average and Instantaneous High Total Dissolved Gas Saturation (%) at Upper and Middle Columbia Stations

	Boundary Waters		Grand Coulee		Chid		Joseph		Wells		Rocky Reach		Rock Island		Wanapum		Below Wanapum (4		Priest Rapids (2.4mi)		Priest Rapids	
	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High
5/11	114	119	106	107	105	105	108	109	108	108	110	111	112	113	119	127	—	—	115	119		
05/12	117	119	107	108	105	106	109	109	107	107	110	112	112	113	117	126	118	120	112	117		
05/13	117	121	106	107	105	105	108	109	105	106	109	111	109	111	115	125	114	120	110	113		
05/14	117	122	106	107	—	—	107	109	105	106	108	110	109	110	114	125	115	121	109	110		
05/15	116	121	107	108	—	—	108	109	108	109	108	109	110	112	118	124	117	121	110	113		
05/16	114	120	107	108	—	—	108	108	109	110	109	110	110	112	117	127	115	119	109	112		
05/17	116	120	107	108	107	108	108	109	—	—	—	—	109	111	117	126	115	121	110	113		
05/18	115	120	106	107	106	107	108	108	109	111	109	111	106	109	116	126	115	120	109	114		
05/19	114	117	106	107	107	108	107	107	110	111	110	111	107	108	116	126	114	118	110	113		
05/20	112	116	107	108	107	108	108	108	109	111	109	111	108	109	116	126	114	119	110	113		
05/21	112	113	107	108	107	108	108	108	109	111	109	111	106	110	126	127	115	124	110	114		
05/22	112	113	106	108	107	108	108	108	108	109	108	109	107	110	—	—	116	120	111	115		
05/23	113	116	106	107	107	107	108	109	108	109	108	109	108	111	—	—	120	124	115	118		
05/24	112	113	107	108	107	108	109	110	109	109	109	109	109	110	—	—	119	127	116	120		

Daily Average and Instantaneous High Total Dissolved Gas Saturation (%) at Snake Basin Stations

	Dworshak		Lower Granite		Lower Granite Tailrace		Almota (6 mi below LGR)		Little Goose		Little Goose Tailrace		Lower Monumental		Lower Monumental Tailrace		Ice Harbor		Below Ice Harbor (3.6 mi)		Below Ice Harbor (redundant)		Hood Park Bridge	
Date	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High
05/11	108	110	103	104	105	113	---	---	104	106	116	117	113	114	--	---	112	114	128	135	---	---	113	115
05/12	105	109	103	104	110	122	107	120	105	106	115	117	112	113	113	124	111	113	122	127	---	---	112	115
05/13	98	99	102	103	111	121	111	121	104	105	115	120	111	112	113	116	112	113	121	121	---	---	112	114
05/14	99	99	104	105	114	122	112	121	105	106	118	119	112	112	114	118	110	114	121	122	120	121	113	115
05/15	108	117	103	104	118	121	111	120	109	111	115	118	112	113	112	115	112	113	122	122	121	121	113	113
	116	117	103	104	---	---	111	121	108	110	118	118	112	113	114	117	111	112	121	122	120	121	113	114
	116	116	102	103	111	122	110	121	107	108	116	118	111	113	112	116	110	111	121	121	120	121	112	113
05/18	116	116	102	104	112	123	112	121	107	109	116	118	113	114	114	116	111	113	120	121	120	121	113	114
05/19	115	116	103	104	112	121	120	121	108	109	114	118	114	115	114	116	111	111	121	122	120	121	112	113
05/20	117	120	103	104	111	119	—	—	107	107	114	118	114	115	114	117	111	112	121	122	120	121	112	114
05/21	119	120	104	107	111	118	—	—	107	109	115	117	112	113	113	117	109	114	121	122	120	122	112	115
05/22	119	120	104	105	111	118	—	—	109	110	115	117	112	113	115	118	112	114	120	121	120	122	113	115
05/23	119	120	105	106	---	—	—	—	110	115	—	—	114	115	—	- -	113	115	121	121	121	122	113	116
05124	119	120	107	110	—	—	---	—	113	115	-	—	114	116	—	- -	115	119	121	122	121	122	114	117

Daily Average and Instantaneous High Total Dissolved Gas Saturation (%) at Lower Columbia Stations

	McNary North		McNary South		McNary South (redundent)		McNary Tailrace		John Day		The Dalles		The Dalles (redundent)		Boneville		Warrendale		Warrendale (redundent)		Skamania		Camas/ Washougal		Kalama		Wauna Mill	
Date	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High
05/11	119	121	116	121	—	—	115	117	113	114	112	115	—	—	111	113	115	120	---	—	—	—	—	—	114	116	111	113
05/12	117	118	117	122	—	—	115	117	112	112	108	113	—	—	110	112	114	119	—	—	117	126	110	114	113	116	110	111
05/13	115	117	115	121	—	—	116	120	111	112	110	114	-	—	112	114	115	118	—	—	117	124	107	113	113	116	109	110
05/14	116	118	114	117	114	117	117	121	113	116	113	117	111	114	114	119	115	119	—	—	117	120	107	112	113	116	110	111
05/15	115	117	113	114	113	114	115	117	113	113	113	116	107	113	115	118	116	119	—	—	118	122	107	110	114	115	111	111
05/16	113	114	114	118	114	118	115	120	111	112	112	113	112	119	115	116	116	117	---	---	118	123	106	110	112	113	109	111
05/17	112	114	112	114	112	114	114	118	110	111	--	--	118	120	113	115	114	118	---	---	116	120	105	108	112	113	107	109
05/18	110	112	110	112	110	112	113	119	109	110	—	—	116	117	111	115	114	115	---	---	115	120	105	109	112	113	107	108
50/19	109	110	109	110	109	110	113	118	109	110	109	110	117	118	111	111	113	116	111	112	114	119	104	107	112	113	107	109
05/20	110	110	109	109	109	109	114	118	108	109	108	110	117	118	110	111	112	114	111	113	114	118	104	107	111	112	107	108
05/21	111	114	111	118	110	114	—	—	107	108	107	110	116	118	111	116	113	114	112	114	116	120	105	111	111	113	107	107
0	12	114	112	120	112	121	—	—	107	109	106	110	114	118	113	116	114	115	114	115	117	121	106	111	111	114	106	108
0.	15	12	111	116	112	116	—	—	110	113	108	110	115	117	113	115	114	117	114	116	117	121	107	112	112	114	106	108
05/24	117	122	114	119	114	119	---	---	111	115	110	113	118	120	115	118	116	117	115	116	118	121	108	112	113	116	107	111

Data provided by The Corps of Engineers. Tailrace gauges are manually downloaded by Walla Walla Disrrict and forwarded through the Reservoir Control Center. Data from all other stations arc collected via the GOES satellite network.

Daily Average and Instantaneous High Total Dissolved Gas Saturation (%) at Upper and Middle Columbia Stations

	Boundary Waters		Grand Coulee		Chief Joseph		Wells		Rocky Reach		Rock Islands		Wanapum		Below Wanapum (4mi)		Priest Rapids (2.4mi)		Below Priest Rapids	
	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High							Avg	High	.Ave	High
05/25	112	114	108	109	108	109	111	113	108	109	108	109	111	113	---	---	119	124	116	119
05/26	113	114	109	109	109	109	110	,I,	108	109	108	109	109	111	---	---	114	118	112	115
05/27	113	114	108	109	IO8	109	109	112	108	109	108	109	106	108	122	134	113	124	109	115
05/28	113	114	108	109	108	109	107	108	107	108	107	108	105	106	120	134	115	127	112	117
05/29	113	114	108	110	108	109	107	107	109	110	109	110	107	108	119	130	117	126	110	117
05130	112	114	108	109	107	108	106	107	107	109	107	109	106	107	117	129	116	125	110	116
05/31	113	114	108	110	108	108	107	108	107	107	107	107	107	110	119	129	119	126	114	118
06/01	112	113	108	109	108	109	107	108	107	108	107	108	107	109	114	128	115	122	112	117
06/02	113	120	108	109	108	109	108	109	108	111	108	III	104	106	114	125	110	II8	108	113
06/03	117	122	109	110	109	110	110	111	109	110	109	110	104	106	109	123	119	126'	110	113
06/04	116	119	109	109	109	109	110	I!,	109	109	109	109	105	106	108	111	110	111	106	108
06/05	119	120	109	110	109	110	108	109	---	---	---	. -	105	107	109	110	108	110	105	106
06/06	118	119	109	110	109	109	108	109	107	108	107	108	105	106	109	111	110	113	107	108
06/07	118	119	108	109	108	108	107	108	108	108	108	108	104	105	107	110	108	111	106	107

Daily Average and Instantaneous High Total Dissolved Gas Saturation (%) at Snake Basin Stations

	Dworshak		Lower Granite		Lower Granite Tailrace		Almota (6 mi below LGR)		Little Goose		Littlle Goose Tailrace		Lower Monumental		Lower Monumental Tailrace		Ice Harbor		Below Ice Harbor (3.6 mi)		Below Ice Harbor (redundant)		Hood Park Bridge	
Date	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High
05/25	120	121	108	112	113	119	119	119	113	114	115	116	115	116	115	118	116	118	119	122	118	122	115	118
05/26	120	120	107	109	112	119	---	---	111	112	114	115	116	117	117	118	115	117	121	122	120	121	110	116
05/27	115	120	106	107	111	119	----	---	110	111	114	116	115	116	116	118	113	115	121	122	119	119	114	115
05/28	101	103	104	105	109	114	---	---	110	110	110	112	113	114	113	115	113	113	121	122	---	---	113	113
	101	102	104	104	109	114	—	- -	109	110	109	109	112	113	113	114	112	113	121	122	—	—	112	113
	109	115	103	105	109	115	- -	---	108	109	1096	109	109	111	112	115	110	113	120	122	---	--	112	115
	111	112	102	103	113	114	- -	---	109	109	109	109	109	110	111	114	110	112	121	122	---	---	112	113
06/01	110	111	100	101	---	---	---	—	107	108	—	—	107	108	112	114	104	109	121	122	—	—	112	113
06/02	112	117	103	106	—	—	—	---	107	108	---	---	109	114	---	---	106	115	121	123	---	---	112	115
06/03	117	120	104	108	—	—	—	---	107	108	----	--	109	110	—	—	111	112	121	122	---	---	113	115
06/04	117	118	102	103	---	---	—	---	106	106	---	--	108	109	---	---	109	110	121	122	---	---	112	115
06/05	117	119	104	105	---	---	—	---	106	106	----	----	108	110	---	- -	110	112	121	122	---	---	113	115
06/06	116	117	103	104	---	- -	—	---	105	107	---	---	108	109	---	---	109	110	120	122	---	---	111	113
06107	116	117	101	102				---	105	106	----	----	106	107	----	----	105	108	121	122	...	---	111	113

Daily Average and Instantaneous High Total Dissolved Gas Saturation (%) at Lower Columbia Stations

	McNary North		McNary South		McNary South (redundant)		McNary Tailrace		John Day		The Dalles		The Dalles (redundant)		Bonneville		Warrendale		Warrendale (redundant)		Skamania		Camas/ Washougal		Kalama		Wauna Mill	
Date	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High
05/25	117	120	117	122	117	123	117	120	109	113	110	112	118	121	114	117	114	117	114	116	116	120	107	110	113	115	108	110
05/26	116	117	116	118	116	118	117	121	108	109	106	108	110	118	110	115	112	115	112	115	115	120	104	108	112	113	108	109
05/27	110	115	111	116	115	115	115	123	---	---	106	108	103	103	106	109	111	113	113	113	113	117	103	107	110	111	107	108
05/28	112	114	112	114	---	- -	112	114	---	---	106	108	---	---	106	107	111	112	---	---	112	113	101	103	109	111	106	107
05/29	111	112	111	112	---	---	111	114	---	---	106	107	---	- -	107	108	111	112	- -	- -	112	113	102	103	108	109	105	106
05130	110	114	111	115	---	---	111	115	- -	---	---	---	---	- -	108	111	112	113	---	---	114	115	103	106	109	111	104	106
05/31	111	112	109	111	---	- -	111	117	104	104	---	---	- -	- -	110	112	112	113	---	---	115	117	102	104	110	110	105	107
06/01	109	110	109	111	---	- -	114	116	103	104	---	---	---	---	108	111	112	113	---	- -	113	114	109	115	108	110	103	105
06102	111	115	111	114	---	---	---	---	105	107	---	---	---	---	108	110	112	113	---	---	113	114	112	113	110	112	104	105
06/03	113	118	111	113	---	---	---	---	106	106	---	---	---	---	109	110	113	114	- -	---	114	115	112	115	111	112	104	105
	114	116	114	117	---	---	---	---	104	104	---	---	---	---	108	109	112	113	---	---	114	115	112	114	110	111	103	104
	113	115	114	117	---	---	---	---	104	104	---	---	---	---	109	110	113	114	---	---	114	115	112	114	111	112	103	104
	110	111	110	111	- -	---	---	---	104	104	---	---	---	---	108	109	113	114	---	- -	114	114	112	113	110	111	103	103
06/07	108	109	108	109	- -	---	- -	---	104	104	---	---	---	---	106	107	112	113	---	- -	113	114	111	113	109	110	102	103

Data provided by the Corps of Engineers. Tailrace gauges are manually downloaded by Walla Walla District and forwarded through the Reservoir Control Center. Data from all other stations are collected via the GOES satellite network.

Daily Average and Instantaneous High Total Dissolved Gas Saturation (%) at Upper and Middle Columbia Stations

	Boundary Waters		Grand Coulee		Chief Joseph		Wells		Rocky Reach		Rock Island		Wanapum		Below Wanapum (4 mi)		Priest Rapids (2.4 mi)		Below Priest Rapids	
	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High
05/30	112	114	108	109	107	108	106	107	107	109	107	109	106	107	117	129	116	125	110	116
05/31	113	114	108	110	108	108	107	108	107	107	107	107	107	110	119	129	119	126	114	118
06/01	112	113	108	109	108	109	107	108	107	108	107	108	107	109	114	128	115	122	112	117
06/02	113	120	108	109	108	109	108	109	108	111	108	111	104	106	114	125	110	118	108	113
06/03	117	122	109	110	109	110	110	111	109	110	109	110	104	106	109	123	119	126	110	113
06/04	116	119	109	109	109	109	110	111	109	109	109	109	105	106	108	111	110	111	106	108
06/05	119	120	109	110	109	110	108	109	----	----	----	----	105	107	109	110	108	110	105	106
06/06	118	119	109	110	109	109	108	109	107	108	107	108	105	106	109	111	110	113	107	108
06/07	118	119	108	109	108	108	107	108	108	108	108	108	104	105	107	110	108	111	106	107
06/08	118	119	107	109	107	108	107	108	107	108	107	108	103	105	106	107	106	107	104	105
06/09	117	119	107	108	107	108	107	108	108	109	108	109	105	106	107	107	106	108	104	105
06/10	115	119	108	109	108	108	108	108	109	109	109	109	106	107	108	111	108	110	106	107
06/11	117	119	109	109	108	109	108	109	110	111	110	111	108	109	110	118	112	119	108	111
06/12	116	119	109	110	109	109	109	109	109	110	109	110	108	109	113	131	113	122	109	113

Daily Average and Instantaneous High Total Dissolved Gas Saturation (%) at Snake Basin Stations

	Dworshak		Lower Granite		Lower Granite Tailrace		Almota (4 mi below LGR)		Little Goose		Little Goose Tailrace		Lower Monumental		Lower Monumental Tailrace		Ice Harbor		Below Ice Harbor (3.6 mi)		Below Ice Harbor (redundant)		Hood Park Bridge	
Date	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High
05/30	109	115	103	105	109	115	110	117	108	109	109	109	109	111	112	115	110	113	120	122	----	----	112	115
05/31	111	112	102	103	107	114	108	116	109	109	108	109	109	110	111	114	110	112	121	122	----	----	112	113
06/01	110	111	100	101	108	115	108	116	107	108	107	108	107	108	111	115	104	109	121	122	----	----	112	113
06/02	112	117	103	106	109	115	109	117	107	108	106	107	109	114	111	115	106	115	121	123	----	----	112	115
06/03	117	120	104	108	109	114	109	115	107	108	----	----	109	110	111	114	111	11.2	121	122	----	----	113	115
	117	118	102	103	108	114	109	116	106	106	----	----	108	109	110	114	109	110	121	122	----	----	112	115
	117	119	104	105	107	114	108	116	106	106	111	111	108	110	111	114	110	112	121	122	- -	----	113	115
06/06	116	117	103	104	109	116	109	116	105	107	108	111	108	109	110	113	109	110	120	122	----	----	111	113
06/07	116	117	101	102	112	115	116	116	105	106	109	110	106	107	110	113	105	108	121	122	----	----	111	113
06/08	116	117	100	101	----	----	----	----	104	105	- -	----	105	106	----	----	106	108	120	122	----	----	112	115
06/09	116	119	100	102	----	- -	----	----	104	105	----	----	106	106	----	----	107	108	120	122	----	----	112	117
06/10	115	118	103	107	----	----	----	- -	106	111	----	----	108	113	----	----	109	111	120	121	----	----	114	120
06/11	115	117	105	108	----	----	----	----	111	112	- -	- -	109	111	----	----	110	112	120	122	----	----	114	120
06/12	116	118	103	104	----	----	----	---	110	110	----	----	108	110	----	----	108	111	120	122	119	120	115	117

Daily Average and Instantaneous High Total Dissolved Gas Saturation (%) at Lower Columbia Stations

	McNary North		McNary South		McNary South (redundant)		McNary Tailrace		John Day		The Dalles		The Dalles (redundant)		Bonneville		Warrendale		Warrendale (redundant)		Skamania		Camas/ Washougal		Kalama		Wauna Mill	
Date	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High
05/30	110	114	111	115	----	----	111	115	----	----	----	- -	----	----	108	111	112	113	----	- -	114	115	103	106	109	111	104	106
05131	111	112	109	111	- -	----	111	117	104	104	----	----	-	-	110	112	112	113	----	----	115	117	102	104	110	110	105	107
06/01	109	110	109	111	----	----	112	116	103	104	----	----	-	-	108	111	112	113	----	----	113	114	109	115	108	110	103	105
06/02	111	115	111	114	----	----	108	117	105	107	----	----	-	-	108	110	112	113	- -	----	113	114	112	113	110	112	104	105
06/03	113	118	111	113	----	----	----	----	106	106	----	----	- -	---	109	110	113	114	----	- -	114	115	112	115	111	112	104	105
06/04	114	116	114	117	- -	----	115	115	104	104	- -	----	----	----	108	109	112	113	---	----	114	115	112	114	110	111	103	104
06/05	113	115	114	117	----	- -	113	115	104	104	----	----	----	----	109	110	113	114	----	----	114	115	112	114	111	112	103	104
06106	110	111	110	111	----	----	112	115	104	104	---	----	----	----	108	109	113	114	---	----	114	114	112	113	110	111	103	103
06107	108	109	108	109	----	----	111	115	104	104	---	- -	----	----	106	107	112	113	- -	----	113	114	111	113	109	110	102	103
06/08	106	107	107	110	----	.--	111	114	103	104	106	108	----	----	106	108	112	113	---	----	113	114	112	115	109	111	102	103
06/09	108	109	109	114	- -	----	----	----	104	104	106	108	----	----	108	110	113	114	---	---	114	116	112	116	111	113	103	104
	111	114	112	120	----	----	----	----	104	106	107	109	----	----	109	111	114	116	----	----	116	119	114	117	111	113	103	105
0	112	115	113	118	----	- -	----	----	104	105	107	108	----	----	109	110	114	115	----	----	116	116	114	116	112	113	104	105
06112	111	113	113	115	112	114	- -	----	104	105	105	109	105	106	108	110	113	114	113	114	115	116	113	115	112	113	104	105

Data provided by the Corps Of Engineers. Tailrace gauges are manually downloaded by Walla Walla District and forwarded through the Reservoir Control Center. Data from all other stations arc collected via the GOES satellite network.

Daily Average and Instantaneous High Total Dissolved Gas Saturation (%) at Upper and Middle Columbia Stations

	Boundary Waters		Grand Coulee		Chief Joseph		Wells		Rocky Reach		Rock Island		Wanapum		Below Wanapum (4		Priest Rapids (2.4 mi)		Below Priest Rapids	
	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High
06/13	114	119	110	111	109	110	108	109	108	108	108	108	108	109	113	117	111	116	107	110
06/14	112	113	109	110	108	108	107	108	107	108	107	108	106	107	109	112	114	117	108	110
06/15	112	117	108	110	107	108	107	107	---	---	---	--	104	105	107	107	109	113	105	106
06/16	115	118	107	108	107	108	107	108	108	109	108	109	104	106	--	---	106	107	104	105
06/17	112	115	107	108	107	108	107	108	109	112	109	112	105	107	109	110	107	108	105	106
06/18	112	116	107	108	107	108	108	108	109	111	109	111	105	106	108	110	106	108	104	105
06/19	112	116	107	107	107	108	107	108	109	111	109	111	104	106	109	111	107	110	104	106
06/20	113	118	107	108	107	108	107	108	108	110	108	110	106	110	110	111	109	110	106	108
06/21	113	119	107	108	108	108	108	108	111	112	111	112	108	110	--	--	111	114	108	111
06/22	114	119	107	108	107	108	108	108	110	111	110	111	108	111	112	114	111	113	108	109
06/23	--	--	107	108	--	--	108	108	110	110	1.10	110	109	113	113	121	111	114	108	111
06/24	---	---	107	107	---	--	107	108	110	111	110	111	106	108	110	110	110	113	107	109
06/25	--	--	108	109	--	--	108	109	109	112	109	112	107	109	111	112	110	111	107	108
06126	--	--	107	108	--	--	107	108	108	108	108	108	105	109	109	111	107	109	105	106

Daily Average and Instantaneous High Total Dissolved Gas Saturation (%) at Snake Basin Stations

	Dworshak		Lower Granite		Lower Granite Tailrace		Almota (4 mi below LGR)		Little Goose		Little Goose Taihace		Lower Monumental		Lower Monumental Tailrace		Ice Harbor		Below Harbor (3.6 mi)		Below Ice Harbor (redundant)		Hoed Park Bridge	
Date	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High
06/13	116	118	104	106	108	112	114	115	107	110	109	110	108	109	110	112	111	111	120	121	118	120	115	115
06/14	116	117	104	105	--	--	--	---	106	106	---	---	106	107	--	---	108	109	122	124	117	118	111	114
06/15	116	118	102	104	--	--	--	--	104	105	--	--	104	106	--	--	106	108	123	127	116	120	111	120
06/16	116	118	101	103	--	--	--	---	102	103	--	---	104	104	--	--	105	107	--	--	113	122	109	112
	116	119	102	104	--	--	--	--	106	111	--	--	106	111	--	--	107	111	--	--	114	122	110	113
	116	118	98	102	--	--	--	--	104	111	---	--	106	112	--	--	106	107	--	--	114	120	110	112
	116	119	98	100	--	--	--	---	106	112	---	--	105	112	--	--	107	116	--	--	114	121	121	128
06/20	113	116	100	100	---	--	--	---	107	111	--	--	108	111	--	--	108	113	--	--	118	121	126	127
06/21	111	115	100	102	--	--	--	--	105	108	--	--	105	110	--	--	109	115	---	---	---	---	121	126
06/22	111	114	106	117	--	--	--	---	108	117	--	--	108	114	--	--	108	112	--	--	113	114	111	114
06/23	111	114	109	113	--	--	--	--	103	114	--	--	106	110	--	--	105	110	--	--	111	112	109	112
06/24	111	113	104	106	---	--	--	--	100	104	--	--	105	108	--	--	105	109	--	--	111	113	108	112
06/25	110	113	106	108	--	--	--	---	104	106	--	--	105	107	--	--	105	106	110	114	--	--	109	112
06/26	110	112	103	105	--	--	--	--101		103	--	--	102	103	--	--	103	104	108	110	--	--	106	111

Dally Average and Instantaneous High Total Diilved Gas Saturation (%) at Lower Columbia Stations

	McNary North		McNary South		McNary South (redundant)		McNary Tailrace		John Day		The Dalles		The Dalles (redundant)		Bonneville		Warrendale		Warrendale (redundant)		Skamania		Camas/ Washougal		alama		Wauna Mill	
Date	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High
06/13	110	112	110	112	110	111	112	114	104	105	106	109	105	105	106	109	111	113	112	114	113	116	111	113	111	112	103	105
06/14	107	108	108	109	107	108	---	--	103	104	105	107	104	104	104	104	110	111	111	112	111	112	108	110	109	110	105	111
06/15	105	106	107	109	106	109	---	--	102	103	105	106	104	104	105	106	111	112	112	113	111	113	108	111	107	108	110	111
06/16	105	107	108	111	107	111	---	--	101	102	104	106	103	104	106	106	112	113	112	113	112	114	110	113	108	110	109	110
06/17	110	115	108	115	107	113	--	--	101	103	105	107	104	104	107	108	112	113	113	113	112	113	110	112	109	110	109	111
06/18	108	111	109	112	108	110	--	--	100	101	106	107	103	104	107	108	112	113	112	113	113	114	109	112	110	110	109	111
06/19	108	112	110	113	109	112	--	--	101	101	105	110	103	104	107	109	113	114	113	114	114	115	111	114	109	110	110	112
06/20	110	114	108	115	106,	108	---	--	--	--	--	106	107	104	104	109	110	114	115	114	115	115	117	112	115	110	111	110	111
06/21	110	113	111	117	--	--	--	--	--	--	--	106	108	--	--	108	110	113	114	--	--	114	115	112	115	111	113	109	110
06/22	112	114	114	121	112	119	--	--	---	---	---	107	110	104	105	106	112	111	112	112	113	112	113	111	113	112	113	109	111
0'	109	110	111	115	110	113	--	---	---	---	---	105	110	104	105	104	108	109	110	110	111	111	114	108	110	110	112	109	110
	107	111	108	113	108	112	---	--	--	--	---	104	107	103	103	102	106	108	110	110	111	110	111	108	111	109	110	109	109
0.	109	112	110	115	109	114	--	--	--	--	--	106	109	104	105	102	104	108	109	110	110	110	111	107	110	108	109	108	109
06/26	106		107		106		107	105	106	--	--	--	--	--	104	107	102	104	101	104	107	'109	109	110	111	114	106	109	107	108	107	108

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Daily Average and Instantaneous **High** Total Dissolved Gas Saturation (%) at Upper and Middle Columbia Stations

	Boundary		Grand Coulee		Chief Joseph		Wells		Rocky Reach		Rock Island		Wanapum		Below Wanapum		Priest Rapids (2.4)		Below Priest Rapids	
	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High
06/27	—	—	107	108	- -	—	106	107	110	111	110	111	104	106	109	111	106	109	104	105
06/28	—	- -	108	109	- -	- -	107	109	—	—	—	—	107	110	112	113	109	112	107	108
o.so.9	- -	- -	108	109	109	109	108	109	108	109	108	109	108	109	111	112	110	111	107	1078
06/30	- -	- -	- -	- -	109	109	108	109	110	111	110	111	107	110	112	117	109	112	107	111
07/01	- -	- -	—	—	109	109	108	109	110	110	110	110	108	110	114	127	109	111	106	107
07/02	—	—	—	_ _	108	109	107	108	109	111	109	111	106	111	118	127	111	118	106	111
07/03	—	—	—	—	108	109	107	108	106	108	106	108	104	107	116	123	113	117	108	112
07/04	- -	—	—	—	108	109	107	108	106	107	106	107	104	106	119	123	114	116	108	111
07105	- -	- -	—	—	108	109	108	108	107	108	107	108	103	105	119	122	112	114	106	110
07/06	112	112	107	107	108	109	107	108	107	110	107	110	103	10.5	119	123	114	117	109	113
07/07	112	113	108	109	108	110	108	109	- -	—	- -	—	105	107	120	123	118	121	112	115
07/08	111	113	108	109	109	110	109	109	109	111	109	111	107	110	117	121	118	121	112	114
07/09	111	112	108	110	109	110	109	110	110	111	110	111	107	108	117	120	114	116	109	113
07/10	111	112	108	109	108	109	108	109	108	109	108	109	106	108	114	120	111	114	106	109

Daily Average and **Instantaneous** High Total **Dissolved** Gas **Saturation (%)** at Snake Basin Stations

	Dworshak		Lower Granite		Lower Granite Tailrace		Almota (4 mi below LGR)		Little Goose		Little Goose Tailrace		Lower Monumental		Lower Monumental Tailrace		Ice Harbor		Below Ice Harbor (3.6 mi)		Below Ice Harbor (redundant)		Hood Park Bridge	
Date	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High
06/27	110	113	102	105	- - - -	- -	—	103	111	—	—	102	104	- -	—	101	102	109	111	- -	- -	107	111
06/28	111	113	103	106	- - - -	- -	—	109	112	—	- -	103	107	- -	—	104	108	108	112	106	107	107	112
06/29	111	113	101	104	- - —	- -	—	102	108	- -	- -	101	103	- -	—	103	105	109	113	105	106	107	113
06/30	111	113	100	102	- - - -	- -	---	102	104	—	- -	102	104	- -	- -	104	106	108	111	105	106	108	112
	111	113	99	100	—	- -	—	102	103	—	—	102	104	—	—	102	105	109	111	105	106	107	109
	110	112	100	101	—	- -	—	102	102	—	--	102	103	—	- -	102	105	108	110	104	105	107	110
	110	113	102	102	- - —	- -	—	102	102	—	- -	102	104	—	- -	103	105	109	111	100	105	108	112
07/04	111	113	101	103	—	- -	—	102	103	—	—	103	105	—	—	104	107	110	111	104	105	108	113
07/05	109	110	101	102	- - - -	—	—	101	102	- -	- -	101	103	- -	- -	101	108	108	109	104	105	106	108
07/06	104	114	100	103	- - - -	- -	—	100	103	- -	—	101	102	- -	- -	103	107	107	109	103	104	106	110
07107	106	115	101	104	- - - -	- -	—	104	108	—	—	104	110	- -	- -	107	110	107	109	103	104	107	110
07/08	118	121	102	106	- - —	- -	—	106	114	—	—	107	110	- -	- -	108	110	116	392	107	110	107	110
07/09	120	121	101	104	—	- -	—	104	109	- -	—	103	107	- -	- -	107	110	109	110	108	110	107	109
07/10	120	121	100	102	—	- -	—	102	103	—	—	102	105	- -	- -	106	108	109	110	108	110	107	109

Daily Average and Instantaneous High Total Dissolved Gas Saturation (%) at Lower Columbia Station

	McNary North		McNary South		McNary South (redundant)		McNary Tailrace		John Day		The Dalles		The Dalles (redundant)		Bonneville		Warrendale		Warrendale (redundant)		Skamania		Camas/ Washougal		Kalama		Wauna Mill	
Date	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High	Avg	High
06/27	108	113	108	112	107	110	- -	—	104	109	102	103	101	101	109	111	108	108	111	111	109	111	107	107	107	108		
06/28	108	111	110	116	108	114	—	—	106	111	103	104	104	107	110	112	110	112	111	112	109	113	108	109	106	108		
06/29	107	109	111	113	110	113	- -	—	105	111	103	104	101	102	110	112	111	112	111	112	109	112	108	108	105	107		
06/30	108	110	110	112	108	112	- -	—	105	113	102	102	101	104	109	111	111	112	111	114	110	112	108	109	106	107		
07/01	107	108	108	111	107	110	- -	—	103	105	102	102	100	100	108	109	111	112	109	113	108	111	108	109	106	107		
07/02	105	106	106	108	106	107	- -	—	105	111	101	101	99	100	109	111	111	112	109	111	107	109	107	108	10.5	106		
07103	105	107	107	109	106	109	—	—	105	109	100	102	99	100	108	109	111	112	112	114	108	110	106	107	105	106		
07/04	106	108	108	112	107	111	- -	—	105	110	100	102	99	100	108	109	111	112	112	112	108	109	106	107	104	105		
07/05	104	105	104	106	103	105	—	—	102	104	100	101	98	99	108	109	111	112	111	112	108	109	106	107	104	106		
07/06	105	108	106	111	105	110	- -	—	102	109	100	100	100	101	107	109	111	112	110	113	109	111	106	107	104	106		
07	108	112	110	116	108	122	—	—	107	108	103	10.5	100	101	100	101	107	109	111	112	113	116	110	112	107	108	106	108
	110	114	111	118	- -	- -	—	- -	102	106	103	105	103	104	101	102	108	108	111	112	114	115	110	111	107	108	106	107
0.	113	115	115	119	—	—	—	- -	101	102	102	104	103	104	101	101	107	108	111	112	113	114	108	110	107	108	105	107
07/10	112	116	113	116	—	- -	- -	- -	100	101	101	102	101	104	100	100	107	108	111	112	112	115	108	110	107	108	104	106

Data provided by the Corps of Engineers. Tailrace gauges are manually downloaded by Walla Walla District and forwarded through the Reservoir Control Center. Data from all other stations are collected via the GOES satellite network.

1994 Total Dissolved Gas Saturation (%) - Forebay Stations (except Warrendale and Skamania)
Average of 12 highest readings, 24 hour Average, and Highest reading of 24 hour period

	Lower Granite			Little Goose			Lower Monumental			Ice Harbor			McNary North			McNary South			McNary South (redundant)		
	12 h	24 h		12 h	24 h		12 h	24 h		12 h	24 h		12 h	24 h		12 h	24 h		12 h	24 h	
Date	Ave	Avg	High	Avg	Avg	High	Avg	Avg	High	Avg	Avg	High	Avg	Avg	High	Avg	Avg	High	Avg	Avg	High
05111	103	103	104	106	104	106	113	113	114	112	112	114	119	119	121	118	116	121	—	—	—
05/12	103	103	104	105	105	106	112	112	113	112	111	113	117	117	118	119	117	122	—	—	—
05/13	103	102	103	10.5	104	105	112	111	112	112	112	113	116	115	117	118	115	121	—	—	—
05/14	104	104	105	105	105	106	112	112	112	113	110	114	117	116	118	115	114	117	115	114	117
05/15	104	103	104	110	109	111	112	112	113	113	112	113	116	115	117	114	113	114	114	113	114
05/16	103	103	104	109	108	110	113	112	113	112	111	112	114	113	114	115	114	118	115	114	118
05/17	103	102	103	108	107	108	112	111	113	110	1'10	111	113	112	114	113	112	114	113	112	114
05/18	103	102	104	108	107	109	114	113	114	111	111	113	111	110	112,	111	110	112	111	110	112
05119	104	103	104	108	108	109	114	114	115	111	111	Ill	110	109	110	110	109	110	110	109	110
05/20	103	103	104	107	107	107	114	114	115	111	111	112	110	110	110	109	109	109	109	109	109
05/21	105	104	107	108	107	109	112	112	113	112	109	114	112	111	114	112	111	118	111	110	114
05/22	104	104	105	110	109	110	113	112	113	112	112	114	113	112	114	115	112	120	115	112	121
05/23	105	105	106	112	110	115	114	114	115	113	113	115	117	115	121	113	111	116	113	112	116
05/24	108	107	110	114	113	115	115	114	116	116	115	119	119	117	122	117	114	119	117	114	119

	John Day			The Dalles			The Dalles (redundant)			Bonneville			Warrendale			Warrendale (redundant)			Skamania		
	12 h	24 h		12 h	24 h		12 h	24 h		12 h	24 h		12 h	24 h		12 h	24 h		12 h	24 h	
Date	Avg	Avg	High	Avg	Avg	High	Avg	Avg	High	Avg	Avg	High	Avg	Avg	High	Avg	Avg	High	Avg	Avg	High
05/11	113	113	114	113	112	115	—	—	—	112	Ill	113	117	115	120	—	—	—	—	—	—
05/12	112	112	112	113	108	113	—	—	—	111	110	112	116	114	119	—	—	—	120	117	126
05/13	112	111	112	112	110	114	—	—	—	113	112	114	116	115	118	--	—	—	119	117	124
05/14	114	113	116	115	113	117	112	111	114	116	114	119	116	115	119	—	—	—	118	117	120
05115	113	113	113	114	113	116	111	107	113	116	115	118	117	116	119	--	—	—	120	118	122
05/16	111	111	112	112	112	113	115	112	119	115	115	116	116	116	117	—	—	—	119	118	123
05/17	110	110	111	—	—	—	119	118	120	114	113	115	116	114	118	--	—	—	118	116	120
05/18	109	109	110	—	—	—	116	116	117	113	111	115	115	114	115	—	—	—	116	115	120
05/19	109	109	110	109	109	110	118	117	118	111	111	111	114	113	116	111	111	112	116	114	119
05/20	108	108	109	109	108	110	118	117	118	110	110	111	113	112	114	--	111	113	116	114	118
05/21	107	107	108	109	107	110	116	116	118	112	111	116	114	113	114	112	112	114	118	116	120
05/22	108	107	109	108	106	110	117	114	118	114	113	116	115	114	115	114	114	115	119	117	121
05/23	111	110	113	109	108	110	116	115	117	114	113	115	115	114	117	115	114	116	119	117	121
05/24	113	111	115	Ill	110	113	119	118	120	116	115	118	116	116	117	115	115	116	119	118	121

1994 Total Dissolved Gas Saturation (%) - Forebay Stations (except Warrendale and Skamania)
Average of 12 highest readings, 24 hour Average, and Highest reading of 24 hour period

	Lower Granite			Little Goose			Lower Monumental			Ice Harbor			McNary North			McNary South			McNary South (redundant)		
Date	12 h Avg	24 h Avg	High	12 h Avg	24 h Avg	High	12 h Avg	24 h Avg	High	12 h Avg	24 h Avg	High	12 h Avg	24 h Avg	High	12 h Avg	24 h Avg	High	12 h Avg	24 h Avg	High
05/17	103	102	103	108	107	108	112	111	113	110	110	111	113	112	114	113	112	114	113	112	114
05118	103	102	104	108	107	109	114	113	114	111	111	113	111	110	112	111	110	112	111	110	112
05/19	104	103	104	108	108	109	114	114	115	111	111	111	110	109	110	110	109	110	110	109	110
05/20	103	103	104	107	107	107	114	114	115	111	111	112	110	110	110	109	109	109	109	109	109
05/21	105	104	107	108	107	109	112	112	113	112	109	114	112	111	114	112	111	118	111	110	114
05/22	104	104	105	110	109	110	113	112	113	112	112	114	113	112	114	115	112	120	115	112	121
05/23	105	105	106	112	110	115	114	114	115	113	113	115	117	115	121	113	111	116	113	112	116
05/24	108	107	110	114	113	115	115	114	116	116	115	119	119	117	122	117	114	119	117	114	119
05/25	109	108	112	117	113	114	116	115	116	117	116	118	118	117	120	119	117	122	120	117	123
05/26	107	107	109	111	111	112	116	116	117	116	115	117	116	116	117	117	116	118	117	116	118
05/27	106	106	107	110	110	111	115	115	116	114	113	115	114	110	115	115	111	116	115	115	115
05/28	105	104	105	110	110	110	113	113	114	113	113	113	113	112	114	113	112	114	---	---	---
05/29	104	104	104	110	109	110	113	112	113	113	112	113	112	111	112	112	111	112	---	---	---
05/30	104	103	105	109	108	109	110	109	111	111	110	113	111	110	114	113	111	115	---	---	---

	John Day			The Dalles			The Dalles (redundant)			Bonneville			Warrendale			Warrendale (redundant)			Skamania		
Date	12 h Avg	24 h Avg	High	12 h Avg	24 h Avg	Hieh	12 h Avg	24 h Avg	High	12 h Ave.	24 h Avg	High	12 h Avg	24 h Avg	High	12 h Avg	24 h Avg	High	12 h Avg	24 h Ave	High
05/17	110	110	111	---	---	---	119	118	120	114	113	115	116	114	118	---	---	---	118	116	120
05/18	109	109	110	---	---	---	116	116	117	113	111	115	115	114	115	---	---	---	116	115	120
05/19	109	109	110	109	109	110	118	117	118	111	111	111	114	113	116	111	111	112	116	114	119
05/20	108	108	109	109	108	110	118	117	118	110	110	111	113	112	114	---	111	113	116	114	118
05/21	107	107	108	109	107	110	116	116	118	112	111	116	114	113	114	112	112	114	118	116	120
05122	108	107	109	108	106	110	117	114	118	114	113	116	115	114	115	114	114	115	119	117	121
05/23	111	110	113	109	108	110	116	115	117	114	113	115	115	114	117	115	114	116	119	117	121
05/24	113	111	115	111	110	113	119	118	120	116	115	118	116	116	117	115	115	116	119	118	121
05/25	110	109	113	111	110	112	119	118	121	115.	"114	117	115	114	117	115	114	116	118	116	120
05/26	108	108	109	107	106	108	116	110	118	111	110	115	113	112	115	113	112	115	117	115	120
05/27	3 6	30	50	107	106	108	103	103	103	107	106	109	112	111	113	113	113	113	115	113	117
05/28	13	7	50	107	106	108	---	---	---	107	106	107	112	111	112	---	---	- -	112	112	113
05/29	0	0	0	105	102	107	---	---	---	107	107	108	112	111	112	---	---	---	113	112	113
05/30	0	0	0	100	100	100	--	---	---	109	108	111	113	112	113	---	---	---	114	114	115

1994 Total Dissolved Gas Saturation (%) - Forebay Stations (except Warrendale and Skamania)
Average of 12 highest readings, 24 hour Average, and Highest reading of 24 hour period

	Lower Granite			Little Goose			Lower Monumental			Ice Harbor			McNary North			McNary South			McNary South (redundant)		
Date	12 h Avg	24 h Avg	High	12 h Avg	24 h Avg	High	12 h Avg	24 h Avg	Hieh	12 h Ave	24 h Avg	Hieh	12 h Avg	24 h Avg	Hieh	12 h Avg	24 h Avg	High	12 h Avg	24 h Avg	Hieh
05/20	103	103	104	107	107	107	114	114	115	111	111	112	110	110	110	109	109	109	109	109	109
05/21	105	104	107	108	107	109	112	112	113	112	109	114	112	111	114	112	111	118	111	110	114
05/22	104	104	105	110	109	110	113	112	113	112	112	114	113	112	114	115	112	120	115	112	121
05/23	105	105	106	112	110	115	114	114	115	113	113	115	117	115	121	113	111	116	113	112	116
05/24	108	107	110	114	113	115	115	114	116	116	115	119	119	117	122	117	114	119	117	114	119
05/25	109	108	112	117	113	114	116	115	116	117	116	118	118	117	120	119	117	122	120	117	123
05/26	107	107	109	111	111	112	116	116	117	116	115	117	116	116	117	117	116	118	117	116	118
05/27	106	106	107	110	110	111	115	115	116	114	113	115	114	110	115	115	111	116	115	115	115
05/28	105	104	105	110	110	110	113	113	114	113	113	113	113	112	114	113	112	114	---	---	---
05/29	104	104	104	110	109	110	113	112	113	113	112	113	112	111	112	112	111	112	- - -	---	---
05130	104	103	105	109	108	109	110	109	111	111	110	113	111	110	114	113	111	115	-	-	---
05/31	102	102	103	109	109	109	109	109	110	111	110	112	112	111	112	110	109	111	---	---	- -
06/01	101	100	101	107	107	108	108	107	108	109	104	109	110	109	110	110	109	111	---	---	---
06/02	104	103	106	107	107	108	110	109	114	112	106	115	113	111	115	112	111	114	- - -	- -	---

	John Day			The Dalles			The Dalles (redunndant)			Bonneville			Warrendale			Warrendale (redundant)			Skamania		
Date	12 h Avg	24 h Avg	High	12 h Avg	24 h Avg	High	12 h Avg	24 h Avg	Hieh	12 h Avg	24 h Avg	Hieh	12 h Avg	24 h Avg	High	12 h Avg	24 h Avg	High	12 h Avg	24 h Avg	High
05120	108	108	109	109	108	110	118	117	118	110	110	111	113	112	114	--	111	113	116	114	118
05/21	107	107	108	109	107	110	116	116	118	112	111	116	114	113	114	112	112	114	118	116	120
05/22	108	107	109	108	106	110	117	114	118	114	113	116	115	114	115	114	114	115	119	117	121
05/23	111	110	113	109	108	110	116	115	117	114	113	115	115	114	117	115	114	116	119	117	121
05/24	113	111	115	111	110	113	119	118	120	116	115	118	116	116	117	115	115	116	119	118	121
05/25	110	109	113	111	110	112	119	118	121	115	114	117	115	114	117	115	114	116	118	116	120
05/26	108	108	109	107	106	108	116	110	118	111	110	115	113	112	115	113	112	115	117	115	120
05/27	***	***	***	107	106	108	103	103	103	107	106	109	112	111	113	113	113	113	115	113	117
05/28	***	***	***	107	106	108	---	---	---	107	106	107	112	111	112	---	---	---	112	112	113
05/29	***	***	***	105	102	107	- -	---	---	107	107	108	112	111	112	---	--	- -	113	112	113
05/30	***	i i *	***	100	100	100	- -	- -	---	109	108	111	113	112	113	---	---	---	114	114	115
05/31	***	***	***	100	99	100	---	---	- -	111	110	112	113	112	113	---	---	---	115	115	117
06/01	103	103	104	100	100	100	- -	---	---	109	108	111	113	112	113	--	---	- -	114	113	114
06102	106	105	107	100	100	100	---	---	---	109	108	110	112	112	113	--	---	---	113	113	114

Erroneous data (< 100%) have been replaced with asterisks.

1994 Total Dissolved Gas Saturation (%) - Forebay Stations (except Warrendale and Skamania)
Average of 12 highest readings, 24 hour Average, and Highest reading of 24 hour period

	Lower Granite			Little Goose			Lower Monumental			Ice Harbor			McNary North			McNary South			McNary South (redundant)		
	12 h	24 h		12 h	24 h		12 h	24 h		12 h	24 h		12 h	24 h		12 h	24 h		12 h	24 h	
Date	Avg	Ave	High	Avg	Ave	High	Avg	Ave	Hieh	Avg	Avg	Hieh	Avg	Avg	High	Ave	Avg	Hieh	Avg	Avg	Hieh
05/30	104	103	105	109	108	109	110	109	111	111	110	113	111	110	114	113	111	115	---	---	---
05/31	102	102	103	109	109	109	109	109	110	111	110	112	112	111	112	110	109	111	---	---	- -
06101	101	100	101	107	107	108	108	107	108	109	104	109	110	109	110	110	109	111	---	---	---
06/02	104	103	106	107	107	108	110	109	114	112	106	11.5	113	111	115	112	111	114	- -	---	---
06/03	105	104	108	107	107	108	110	109	110	111	111	112	116	113	118	112	111	113	- -	---	---
06104	103	102	103	106	106	106	108	108	109	110	109	110	115	114	116	116	114	117	- -	---	- -
06105	104	104	105	106	106	106	108	108	110	111	110	112	114	113	115	115	114	117	---	---	- -
06/06	103	103	104	106	105	107	108	108	109	109	109	110	110	110	111	110	110	111	- -	---	- -
06/07	102	101	102	106	105	106	106	106	107	107	105	108	108	108	109	108	108	109	---	---	- -
06/08	101	100	101	105	104	105	105	105	106	107	106	108	106	106	107	108	107	110	- -	---	---
06109	100	100	102	104	104	105	106	106	106	107	107	108	108	108	109	113	109	114	---	- -	- -
06/10	104	103	107	108	106	111	109	108	113	109	109	111	112	111	114	116	112	120	- -	---	---
06/11	106	105	108	111	111	112	110	109	111	111	110	112	113	112	115	116	113	118	---	- -	- -
06/12	103	103	104	110	110	110	109	108	110	110	108	111	112	111	113	114	113	115	113	112	114

	John Day			The Dalles			The Dalles (redundant)			Bonneville			Warrendale			Warrendale (redundant)			Skamania		
	12 h	24 h		12 h	24 h		12 h	24 h		12 h	24 h		12 h	24 h		12 h	24 h		12 h	24 h	
Date	Ave	Avg	Hieh	Avg	Avg	Hieh	Avg	Avg	Hieh	Avg	Avg	Hieh	Avg	Avg	High	Avg	Avg	Hieh	Avg	Avg	Hinh
05,330	--	---	---	---	---	---	---	---	- -	109	108	111	113	112	113	---	- -	---	114	114	115
05/31	104	104	104	---	--	- -	---	---	---	111	110	112	113	112	113	---	---	- -	115	115	117
06/01	103	103	104	---	---	- -	---	--	---	109	108	111	113	112	113	---	- -	---	114	113	114
06102	106	105	107	---	---	---	---	--	- -	109	108	110	112	112	113	---	---	---	113	113	114
06103	106	106	106	-	---	- -	--	--	---	109	109	110	113	113	114	---	---	- -	115	114	115
06/04	104	104	104	--	--	---	---	--	---	109	108	109	113	112	113	- -	---	---	114	114	115
06/05	104	104	104	---	--	---	---	---	---	109	109	110	113	113	114	- -	---	- -	115	114	1 1.5
06/06	104	104	104	--	---	- -	---	---	---	108	108	109	113	113	114	---	---	---	114	114	114
06107	104	104	104	--	--	---	---	---	---	107	106	107	112	112	113	---	---	---	114	113	114
06108	104	103	104	106	106	108	---	---	---	107	106	108	112	112	113	---	---	- -	113	113	114
06/09	104	104	104	107	106	108	---	--	---	109	108	110	114	113	114	---	- -	---	115	114	116
06/10	105	104	106	108	107	109	---	---	---	110	109	111	115	114	116	---	---	---	117	116	119
06/11	104	104	105	107	107	108	---	---	---	110	109	110	114	114	115	---	---	---	116	116	116
06/12	104	104	105	107	105	109	106	105	106	109	108	110	114	113	114	114	113	114	115	115	116

1994 Total Dissolved Gas Saturation (%) - Forebay Stations (except Warrendale and Skamania)
Average of 12 highest readings, 24 hour Average, and Highest reading of 24 hour period

	Lower Granite			Little Goose			Lower Monumental			Ice Harbor			McNary North			McNary South			McNary South (redundant))		
	12 h	24 h		12 h	24 h		12 h	24 h		12 h	24 h		12 h	24 h		12 h	24 h		12 h	24 h	
Date	Avg	Avg	High	Avg	Avg	High	Avg	Avg	High	Avg	Avg	High	Avg	Avg	High	Avg	Avg	High	Avg	Avg	High
06/13	105	104	106	109	107	110	109	108	109	111	111	111	111	110	112	111	110	112	111	110	111
06/14	104	104	105	106	106	106	106	106	107	108	108	109	107	107	108	108	108	109	108	107	108
06/15	103	102	104	105	104	105	105	104	106	106	106	108	106	105	106	108	107	109	107	106	109
06/16	102	101	103	103	102	103	104	104	104	106	105	107	106	105	107	109	108	111	109	107	111
06/17	102	102	104	109	106	111	107	106	111	108	107	111	112	110	115	111	108	115	109	107	113
06/18	99	98	102	105	104	111	106	106	112	106	106	107	109	108	111	110	109	112	109	108	110
06/19	99	98	100	108	106	112	106	105	112	109	107	116	110	108	112	111	110	113	110	109	112
06/20	100	100	100	109	107	111	109	108	111	111	108	113	112	110	114	110	108	115	106	106	108
06/21	101	100	102	106	105	108	106	105	110	111	109	115	111	110	113	115	111	117	-	-	-
06/22	111	106	117	111	108	117	110	108	114	109	108	112	113	112	114	118	114	121	116	112	119
06/23	111	109	113	106	103	114	108	106	110	107	105	110	110	109	110	112	111	115	111	110	113
06/24	105	104	106	102	100	104	106	105	108	106	105	109	109	107	111	111	108	'113	110	108	112
06/25	107	106	108	105	104	106	106	105	107	105	105	106	110	109	112	113	110	115	111	109	114
06/26	104	103	105	102	101	103	102	102	103	103	103	104	106	106	107	107	106	107	105	10.5	106

	John Day			The Dalles			The Dalles (redundant)			Bonneville			Warrendale			Warrendale (redundant)			Skamania		
	12 h	24 h		12 h	24 h		12 h	24 h		12 h	24 h		12 h	24 h		12 h	24 h		12 h	24 h	
Date	Avg	Avg	High	Avg	Avg	High	Avg	Avg	High	Avg	Avg	High	Avg	Avg	High	Avg	Avg	High	Avg	Avg	High
06/13	105	104	105	107	106	109	105	105	105	107	106	109	112	111	113	113	112	114	114	113	116
06/14	103	103	104	105	105	107	104	104	104	104	104	104	111	110	111	111	111	112	111	111	112
06/15	103	102	103	105	105	106	104	104	104	106	105	106	112	111	112	112	112	113	112	111	113
06/16	101	101	102	105	104	106	104	103	104	106	106	106	112	112	113	113	112	113	113	112	114
06/17	102	101	103	106	105	107	104	104	104	108	107	108	112	112	113	113	113	113	113	112	113
06/18	101	100	101	106	106	107	104	103	104	108	107	108	112	112	113	113	112	113	113	113	114
06/19	101	101	101	106	105	110	103	103	104	108	107	109	113	113	114	114	113	114	114	114	115
06/20	-	-	-	106	106	107	104	104	104	110	109	110	114	114	115	114	114	115	116	115	117
06/21	-	-	-	106	106	108	-	-	-	109	108	110	113	113	114	-	-	-	114	114	115
06/22	-	-	-	108	107	110	105	104	105	107	106	112	112	111	112	112	112	113	113	112	113
06/23	-	-	-	107	105	110	104	104	105	106	104	108	110	109	110	111	110	111	112	111	114
06/24	-	-	-	105	104	107	103	103	103	,104	102	106	109	108	110	110	110	111	110	110	111
06/25	-	-	-	107	106	109	104	104	105	103	102	104	109	108	109	110	110	110	110	110	111
06/26	-	-	-	105	104	107	103	102	104	101	101	104	108	107	109	109	109	110	112	111	114

Tailwater Instantaneous Total Dissolved Gas Saturation from manually deployed probes

Data collected by the Corps of Engineers

Date	Below John Day Dam		Below The Dalles Dam		Below Bonneville Dam (Hamilton)	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
05/16/94	112%	110%	---	---	---	---
05/17/94	---	---	116%	110%		---
05/18/94	110%	108%	113%	109%	---	---
05/19/94	115%	110%	115%	114%	---	---
05/20/94	114%	113%	114%	112%	---	---
05/21/94	107%	105%	116%	112%	---	---
05/22/94	108%	105%	---	---	---	---
05/23/94	---	---	---	---	---	---
05/24/94	---	---	---	---	---	---
05/25/94	---	---	---	---	---	---
05/26/94	---	---	---	---	---	---
05/27/94	110%	107%	114%	113%	---	---
05/28/94	112%	108%	116%	113%	---	---
05/29/94	113%	108%	115%	114%	---	---
05/30/94	115%	110%	114%	113%	---	---
05/31/94	122%	107%	115%	114%	---	---
06/01/94	110%	106%	---	---	111%	111%
06/02/94	113%	105%	---	---	111%	111%
06/03/94	---	---	---	---	112%	111%
06/04/94	118%	107%	114%	113%	---	---
06/05/94	---	---	---	---	111%	110%
06/06/94	123%	107%	114%	113%	113%	111%
06/07/94	114%	106%	115%	112%	112%	109%
06/08/94	114%	106%	113%	113%	---	---

Tailwater Instantaneous Total Dissolved Gas Saturation from manually deployed probes

Data collected by the Corps of Engineers

Date	Below John Day Dam		Below The Dalles Dam		Below Bonneville Dam (Hamilton)	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
05/18/94	110%	108%	113%	109%	----	- -
05/19/94	115%	110%	115%	114%	----	- -
05/20/94	114%	113%	114%	112%	----	- -
05/21/94	107%	105%	116%	112%	----	----
05/22/94	108%	105%	----	----	----	- -
05/23/94	----	----	----	----	----	----
05/24/94	----		----	----	- -	----
05/25/94	----	----	----	----	----	----
05/26/94	----	----	----	----	----	----
05/27/94	110%	107%	114%	113%	----	----
05/28/94	112%	108%	116%	113%	110%	107%
05/29/94	113%	108%	115%	114%	113%	109%
05/30/94	115%	110%	114%	113%	114%	110%
05/31/94	122%	107%	115%	114%	111%	111%
06/01/94	110%	106%	----	- -	111%	111%
06/02/94	113%	105%	----	111%	111%	
06/03/94	----	----	----	----	112%	111%
06/04/94	118%	107%	114%	113%	----	---
06/05/94	----	----	----	---	111%	110%
06/06/94	-123%	107%	114%	113%	113%	111%
06/07/94	114%	106%	115%	112%	112%	109%
06/08/94	114%	106%	113%	113%	----	----
06/09/94	115%	106%	112%	106%	----	----
06/10/94	121%	106%	115%	112%	- -	----

Tailwater Instantaneous Total Dissolved Gas Saturation from manually deployed probes

Data collected by the Corps of Engineers

Date,	Below John Day Dam		Below The Dalles Dam		Below Bonneville Dam (Hamilton)	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
06/05/94	—	—	—	—	111%	110%
06/06/94	123 %	107%	114%	113%	113%	111%
06/07/94	114%	106%	115%	112%	112%	109%
06/08/94	114%	106%	113%	113%	—	—
06/09/94	115%	106%	112%	106%		—
06/10/94	121%	106%	115%	112%	121%	120%
06/11/94	114%	105%	114%	113%	1 1 4 %	114%
06/12/94	115%	106%	114%	112%	113%	112%
06/13/94	108%	108%	115%	112%	—	—
06/14/94	112%	106%	111%	111%	—	—
06/15/94	107%	105%	112%	111%	—	—
06/16/94	125%	105%	113%	111%	—	—
06/17/94	121%	105%	114%	110%	—	—
06/18/94	117%	109%	107%	106%	109%	109%
06/19/94	125%	111%	110%	110%	111%	109%
06/20/94	—	—	—	—	—	—
06/21/94	—	—	—	—	111%	110%
06/22/94	—	—	—	—	109%	108%
06/23/94	—	—	—	—	—	—
06/24/94	—	—	—	—	—	—
06/25/94		—	—	—	106%	105%
06/26/94	—	—	—	—	—	—
06/27/94	—	—	—	—	109%	109%
06/28/94	—	—	—	—	107%	106%

Tailwater Instantaneous Total Dissolved Gas Saturation from manually deployed probes

Data collected by the Corps of Engineers

Date	Below John Day Dam		Below The Dalles Dam		Below Bonneville Dam (Hamilton)	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
06/27/94	—	—	—	—	109%	109%
06/28/94	—	—	—	—	107%	106%
06/29/94	—	—	—	—	—	—
06/30/94	—	—	—	—	—	—
07/01/94	—	—	—	—	—	—
07/02/94	—	—	—	—	—	—
07/03/94	—	—	—	—	—	—
07/04/94	115%	102%	—	—	—	—
07/05/94	—	—	—	—	117%	116%
07/06/94	125%	102%	—	—	105%	103%
07/07/94	114%	101%	—	—	—	—
07/08/94	—	—	—	—	—	—
07/09/94	—	—	—	—	—	—
07/10/94	—	—	—	—	—	—
07/11/94	—	—	—	—	—	—
07/12/94	—	—	—	—	—	—
07/13/94	—	—	—	—	105%	103%
07/14/94	122%	104%	—	—	103%	103%
07/15/94	111%	104%	—	—	103%	103%
07/16/94	—	—	—	—	103%	102%
07/17/94	—	—	—	—	103%	102%
07/18/94	115%	105%	—	—	103%	102%
07/19/94	—	—	—	—	105%	104%
07/20/94	126%	104%	—	—	104%	103%

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